POWER PLANT ENGINEERING

Established Over 28 Years

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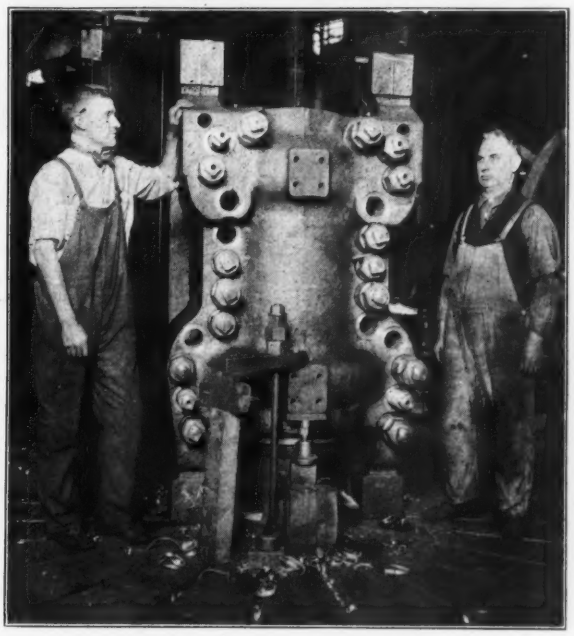
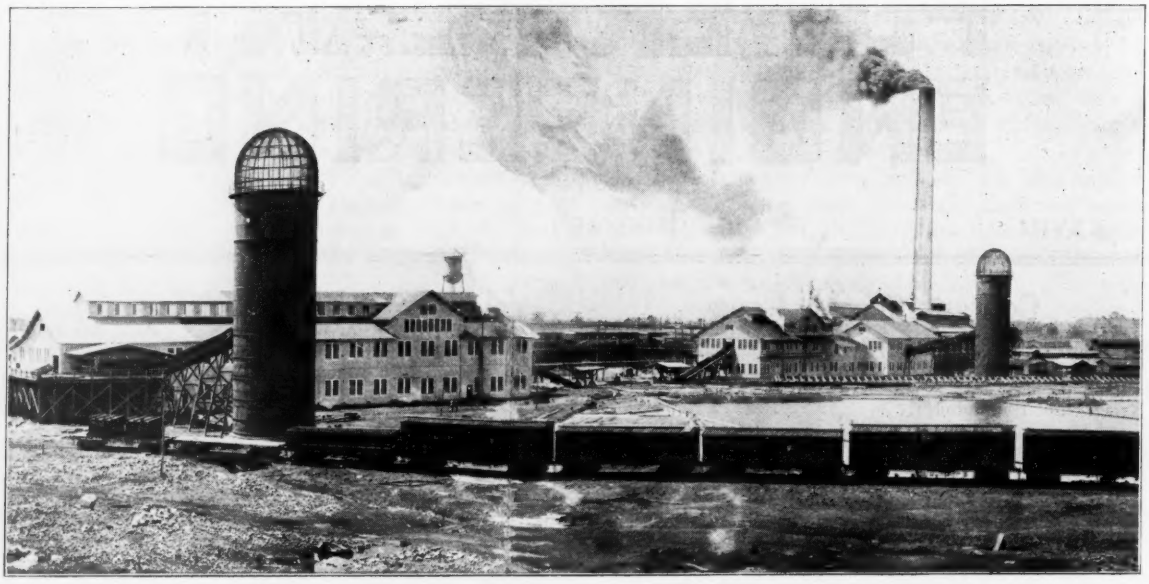


Does Size Mean Anything?

CAN YOU REALIZE that the turbine casing shown above is for a 3150-kw. unit? It is just like asking the question, "How great can a small turbine be?" The steam pressure used is the answer. Compare mentally this 1200-lb. pressure turbine casing with that for a 300-lb. pressure unit and then imagine how the size of a 50,000-kw. capacity turbine would shrink if it were designed for 1200-lb. steam pressure. This unit, which is now being installed in the new Weymouth Station, is fully described on page 805 of this issue.

THEORIES are the foundation stones upon which all engineering is built. Theories, however, are not always sound, and once in a while somebody comes along who shows us that one of our foundation stones is defective. We are then compelled to find a new one. The theory of caustic embrittlement in steam boilers, for instance, has long explained many otherwise mysterious cracks in our boilers and had become quite a favorite with many. Now Mr. Kriegsheim comes along and tells us that the caustic embrittlement theory is a myth. Read about it in this issue.



One New Industrial Power Plant Replaces Seven

ELECTRIFICATION OF A RAPIDLY GROWING LUMBER MILL NECESSITATED SCRAPPING 24 OLD BOILERS AND AN OLD GENERATOR. BY C. B. GORTON AND F. R. INNES

PROGRESSIVENESS IS manifested in two important ways by the Crossett Lumber Co., of Crossett, Ark. One way is that of reforestation of their cutover land and the other is in the recent completion of a modern power plant and the electrification of their mills. The Crossett mills are engaged in the production of short leaf Southern pine and they rank among the great lumber mill undertakings of the country.

Expenditures for extensive power plant and mill improvements have been justified not only by the immediate returns upon greater economy but by looking far into the future and assuring the mills of an adequate supply of timber. Reforestation assures the company that the mills will not dwindle in size as the amount of available timber falls off and it is further a laudable undertaking in that it is the one available means whereby posterity can be assured of its lumber supply.

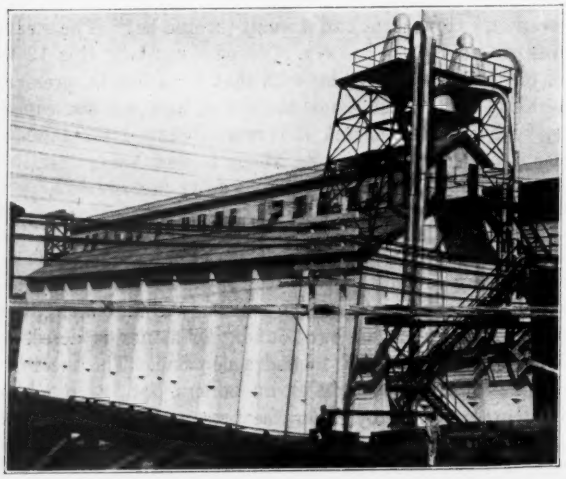


FIG. 1. EXTERIOR VIEW OF THE FUEL HOUSE AND FUEL COLLECTORS

Before going on to describe the power house and its part in this lumber production unit, it should be of interest to review the conditions which the power house supplanted. The Crossett Mills, like many others, had been developing in the past few years from a simple lumber and timber cutting plant into a highly complicated factory unit that produced finished goods instead of just boards, planks and scantlings. Doors, window sash and mouldings, all of which were once the highly specialized products of independent planing mills and wood-working factories became a part of the mill output and uses were found for much of the short lengths of lumber which would otherwise have gone to the burner as waste. These expansions of the lumber mill function required power and the time came when the classic method of setting up a couple of boilers and another steam engine for each additional block of power demand was found to be highly unsatisfactory and uneconomical.

OLD EQUIPMENT HAD TO BE TORN OUT

When the decision was made to build a central power plant and operate the mills by electricity the Crossett Mills harbored no less than 24 fire tube boilers of honorable and honest life but of an age that entitled them to rest. These boilers were squatted about the lot in six separate structures as close as might be to the engines they drove. In addition there was one set which furnished steam to a 125-kw., 220-v. direct-current turbo-generator which supplied light to the mill and town and which operated a few motors in the repair shop.

Construction of the power plant and the electrification of the mills required the consideration of conditions not usual in power plant construction. Provision for the adequate storage and economical handling of the fuel (sawdust, shavings and hogged fuel from the mills) had to be

made and a high pressure steam line about a mile long had to be designed for heating the town.

Before construction was begun on the power house, tests were made to determine whether this structure should or should not be supported on piling. It was at first thought that piling would not be necessary, but a few Arkansas rains had such a deleterious effect on the test platform, which had been erected, that it was apparent that piling was required. The new power house structure consists of a boiler room 160 ft. by 56 ft. and a parallel turbine room 128 ft. by 37 ft. A total of 103 piles were driven, outlining the four walls of the building and the dividing wall between the two rooms. An additional group of 49 piles on 5-ft. centers were driven in the center of the boiler room as a foundation for the stack. The wall piles were cut off and their heads encased in a continuous reinforced concrete capping which formed the base on which the wall footings were poured. The stack piles were capped with a monolith of concrete 32 ft. square with sides rising straight for 4 ft. and then tapering in for an additional 3 ft. of height.

As the concrete block was poured, two mats of reinforcing steel rods were placed in it; one mat resting on the tops of the piles and the other 1 ft. above. The parallel rods of the upper mat are at an angle of 45 deg. with the rods of the lower mat. The reinforcing rods around which the stack was built were carried up out of the concrete base. The stack is of concrete, 275 ft. high and is 20 ft. in dia. at the base.

This power house is a structural steel building with brick walls. Select common brick was used for the faces of the walls and kiln run for backing up. The wall columns, bolted to the footings on 16-ft. centers, were carried up to support the roof trusses, the bottom chords of which, in the boiler room, are 42 ft. above the floor and in the turbine room they are 37 ft. above the floor. The boiler room has a 12-ft. louvred monitor running practically the full length of the roof which is of corrugated steel. The roof of the turbine room is of cement tile. Steel sash and pre-cast concrete sills were built into the walls as they were laid up. All window glass used is white and ribbed vertically.

FIG. 2. BOILERS AND FURNACES DURING CONSTRUCTION

Arrangement of the Turbine Room

General constructional features of the turbine room are the same as for the boiler room, the roof being provided with a ventilated sash monitor which runs the full length of the room. The present turbine equipment consists of four units and space has been left for a fifth unit which will probably be larger than any of those which are now installed. The center axis of the turbines are placed across the room so that the steam ends are near the wall which separates the boiler and turbine rooms. This arrangement provides a convenient and economical arrangement for the high pressure steam piping to the turbines.

Three of the turbines which are installed were made by the General Electric Co. Each is rated at 1500 kw. at 80 per cent power factor, 60 cycles, 3-phase, 3600 r.p.m. and 480 v. The exciters are direct connected and are rated at 18½ kw. and 125 v. The exciter capacity required by each machine is 15½ kw. The specifications call for an air duct to each generator which will allow the delivery of 7000 cu. ft. of air per minute to each generator. The steam consumption of these machines is based on 200 lb. steam pressure at the throttle, 50 deg. F. superheat and a 3-in.

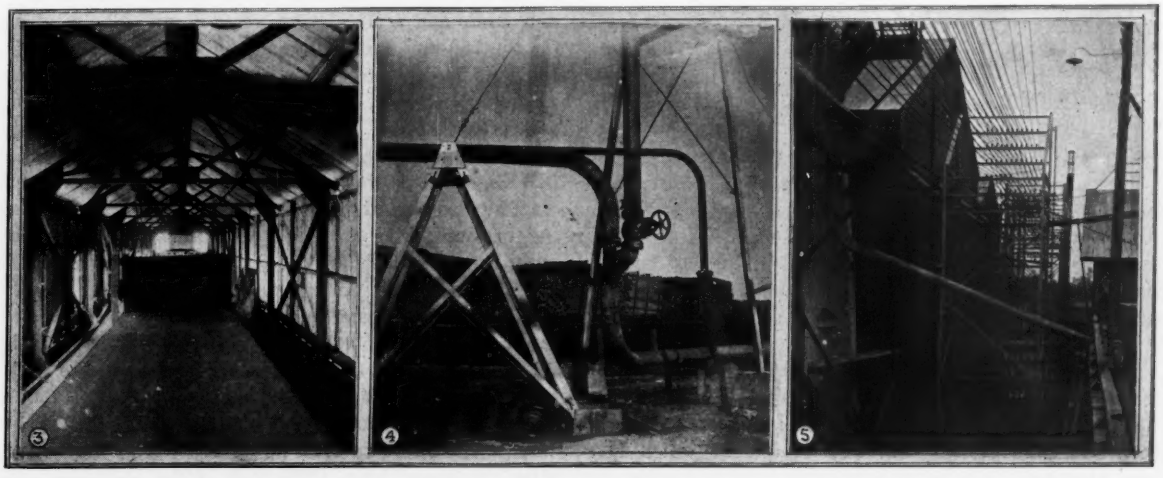


FIG. 3. BELT CONVEYOR AND UNLOADER IN MONITOR OF FUEL HOUSE. FIG. 4. A FRAME ANCHOR AND PIPE BENDS OF OUTSIDE STEAM LINES. FIG. 5. STEEL RACK WHERE THE ELECTRIC FEEDERS TERMINATE

absolute vacuum. Under these conditions the steam consumption will be as follows:

Load kw.	Steam per kw. hr. lb.
750	18.3
1125	17.2
1500	17.1

Allis-Chalmers Mfg. Co. furnished the fourth unit, which is rated at 750 kw. at 80 per cent power factor, 3600 r.p.m., 60 cycles, 3-phase and 480 v. The total weight of this unit is 47,800 lb. and the weight of the heaviest part is 31,360. The steam conditions are 200 lb. pressure at the throttle, 50 deg. F. superheat and a 26-in. vacuum. Excitation is furnished by a direct connected exciter at 125 v. Steam consumption is as follows:

	Load kw.	Lb. Steam per kw. hr. Cond.	Lb. Steam per kw. hr. Non-Cond.
½ load.....	375	22.7	39.1
¾ load.....	562.5	20.0	34.3
Full load.....	750	18.7	34.5

Located in the turbine room and near the 750 kw. turbo-generator is a General Electric Co. synchronous condenser which is rated at 750 kv.a., 900 r.p.m., 480 v., 60 cycles and 3-phase. This machine is automatic in its operation as regards the maintenance of a given power factor. The switch-board is of interesting construction in that it consists of three rows of General Electric Co. truck type switches. These are located at the east end of the turbine room. The overhead crane for the turbine room is of 10-T. capacity and was constructed by the Whiting Corp.

Two stairways lead from the turbine operating floor to the basement. In conformance with good practice these stairs are located at opposite ends of the room so that operators can readily reach any equipment which may need attention.

Lubricating oil is purified by a Wayne Tank & Pump Co. continuous flow filter which is rated at 100 to 200 gal. per hr. The oil returned from the bearings passes through the filter and is then pumped to an overhead tank, the capacity of which is 100 gal. The pump which has been provided is rated at 300 gal. per hr. and is direct connected to a ¼-hp., 440-v., 1750-r.p.m., 3-phase, 60-cycle motor. This pump is of the rotary type and is made of bronze. A wall indicator shows the amount of purified oil in the overhead tank. The oil feed to the turbo generators is by gravity from this pure oil tank.

Each turbine and its generator is supported on a structural steel frame work from the basement floor. Construction of that type occupies the least possible floor space, thus facilitating maintenance work and the illumination of the basement.

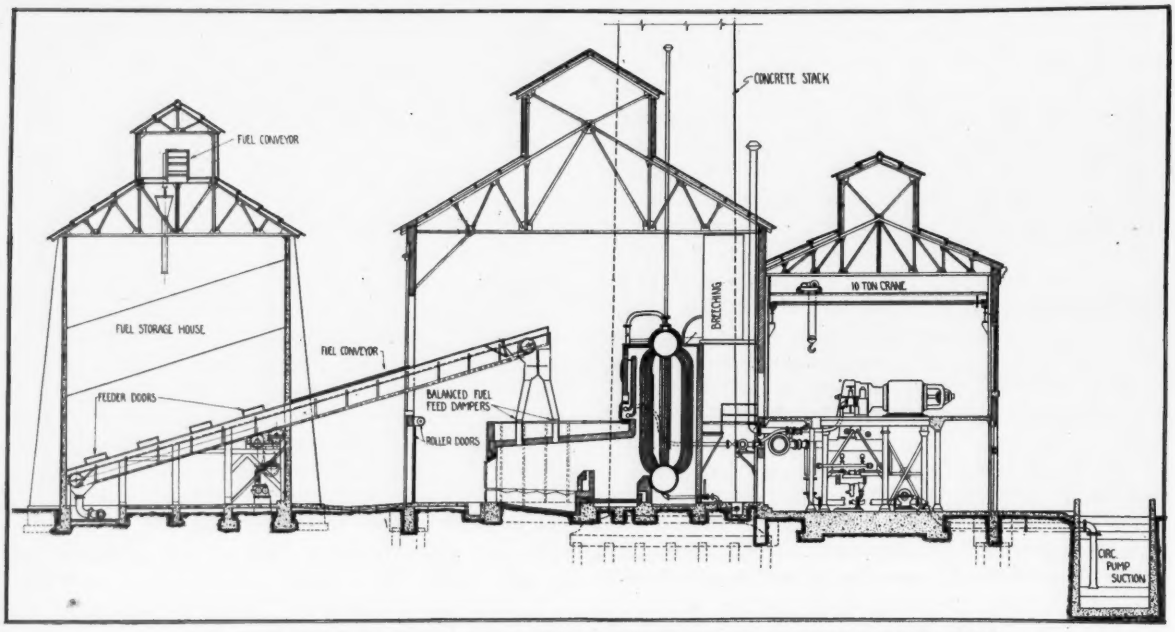


FIG. 6. ELEVATION THROUGH FUEL HOUSE, BOILER HOUSE AND THE TURBINE ROOM

Surface Condensers Are Used

All condensing equipment was furnished by the C. H. Wheeler Mfg. Co., each turbine having been equipped with a four-pass surface condenser, Radojet air pumps, a hot well pump and a circulating water pump. The condenser for the 750-kw. unit contains 1430 sq. ft. of tube surface and it is rated to condense 13,000 lb. of steam per hour when supplied with 1600 gal. of water per min. at a temperature of 85 deg. F. The vacuum to be maintained is 3 in. absolute. The tubes are 1 in. in diameter, No. 18, B.W.G., seamless drawn and are made of Admiralty metal.

Two Radojet air pumps, built for 135 lb. steam working pressure, were installed with this condenser. Each pump has a capacity of 6 cu. ft. of free air per minute at room temperature. An after condenser has been provided to condense the steam from the air pumps. The hot well pump is a 1½-in. centrifugal pump, driven by a 3-hp., 3600-r.p.m., Terry steam turbine. The total head of this pump is 30 ft. The circulating water is handled by an 8-in. centrifugal pump, which is rated at 1600 gal. per min. against a 45 ft. total head. It is direct driven by an Allis-Chalmers 25-hp., 1200-r.p.m., 440-v. induction motor. The brake horsepower required is 24.3.

Each of the three condensers furnished for the 1500-kw.

turbines is rated at 27,000 lb. of steam per hour to be condensed with 3000 gal. of water per min., the temperature of the water being 85 deg. F. and the vacuum to be maintained is 3 in. of mercury, absolute. Each of these condensers has 3260 sq. ft. of 1 in., No. 18, B.W.G., Admiralty metal tubes. The tube sheets are of Muntz metal and the packing is of a fibrous material.

Two Radojets, to operate at 135 lb. steam pressure and each with a capacity of 8 cu. ft. of free air per min., have been furnished with each condenser. Each 2-in. hot well pump will operate against a 30-ft. head. They are driven by 5-hp., 3000-r.p.m. Terry turbines. The Radojets on these units were made complete by the installation of after condensers.

FIG. 7. ROLLER DOORS REPLACE WINDOW SASH OPPOSITE FURNACE FRONTS

Three circulating pumps serve these units. Each is rated at 3000 gal. per min. against a total head of 45 ft. and is driven by a 50-hp., 440-v., 1200-r.p.m. Allis-Chalmers induction motor. The brake horsepower required by each of these pumps is 45.5.

General data on the condenser equipment is as follows:

	750-kw. Unit	Each 1500-kw. Unit
Weight of Condenser empty, lb.	12,000	28,000
Weight of Condenser with water, lb.	15,500	36,500
Number of 12-ft. 2-in. tubes	456	1,036
Friction head through condenser, ft.	19	15
Velocity of water through condenser in ft. per sec.	6.95	5.85

Conditions of operation:

	Lb. Steam per hr.	Water G.P.M.	Temp. of Water deg. F.	Vac. in of Mercury
750-kw. unit:				
	6500	1500	85	2.2
	9750	1500	85	2.4
	13,000	1200	85	3.2
1500-kw. unit:				
	13,000	2900	85	2.2
	19,500	2900	85	2.5
	27,000	2500	85	3.1
	27,000	2000	85	3.6

FIG. 8. FUEL GATES DIRECT THE FUEL TO EITHER FRONT OR REAR FEEDER SPOUTS

Condensing water for the turbines is taken from two ponds which are designated as the log pond and the lily pond. The lily pond has a name which is no longer appropriate because when the new plant was constructed it was drained and drag scrapers were used to clear out the lily plants. These were stacked up into one big pile which required several weeks to burn.

Each Suction Pipe Is Provided with a Foot Valve

Parallel with the turbine room is a concrete trench which is connected to both the lily and the log pond, the latter connection being used for emergency only. The suction pipe from each circulating pump takes water from this concrete trench. The discharge from the condensers is picked up in a large collecting pipe which discharges directly to the log pond. An interesting feature of this installation is that each suction pipe to the circulating pumps is equipped with a strainer and a foot valve.

All water, electric power and steam heat for the town of Crossett is furnished from this plant. The steam heating lines are carried by overhead construction throughout the town.

Six single-unit, 500-hp. Erie City vertical water-tube boilers are placed three on each side of the reinforced-

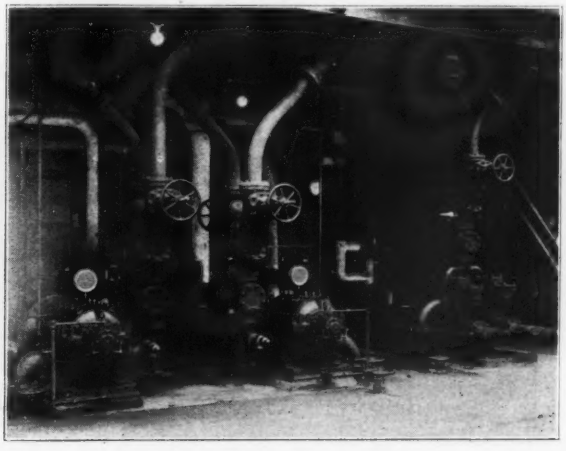


FIG. 9. BOILER FEED AND SERVICE PUMPS ARE LOCATED NEAR THE STACK

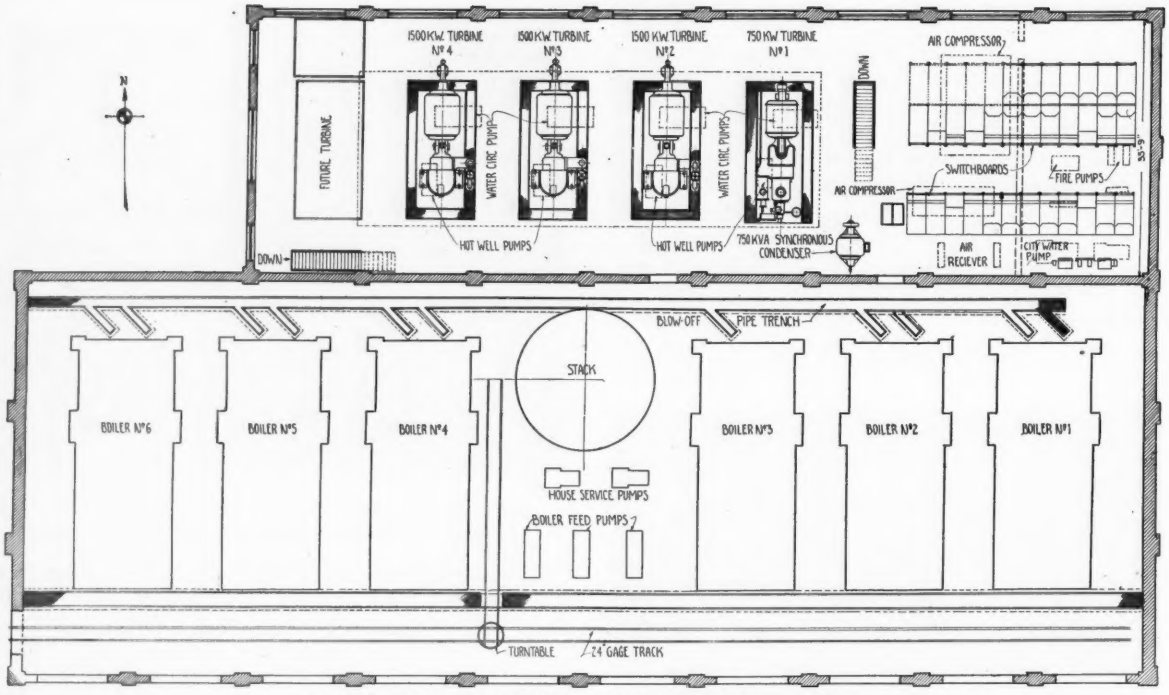


FIG. 10. DRAWING SHOWING PLAN OF THE POWER PLANT

concrete stack which rises out of the center of the boiler room. The boilers are equipped with 21-ft., dutch-oven, flat-grate furnaces with Detrick flat suspension arches. The firing deck, or platform, from which all fuel is fed into the furnaces, rests directly on the dutch ovens and is floored with steel plates. These plates are spanned between furnaces and from the end furnaces to the walls, thus providing a firing deck the full length of the building. Each furnace has four firing holes in the top through which the fuel is fed by means of four spouts from a single hopper. Openings made near the top of the furnace setting allow air to circulate over the arches and beneath the deck plates. Each firing hole is equipped with a balanced damper which automatically tips when a predetermined amount of fuel has been deposited upon it. In this way excess air is excluded from the furnace.

All the boiler feed and service pumps are on the boiler room floor level, the feed water heaters are on the firing deck level and the water storage tanks are located above the heaters. The heaters and storage tanks are supported on a structural steel frame so designed as to give clear space for the installation and operation of pumps and heaters. At the firing deck level the boilers are encircled with walk-ways of steel grating. All the boilers are equipped with Copes feed water regulators and Vulcan soot blowers. The breeching is a steel plate structure and due to the stack being on the center line of the building, consists of two sections.

Main Steam Header Is in Boiler Room

Carried on wall brackets the full length of the building behind the boilers is a 12-in. steel steam header. Behind

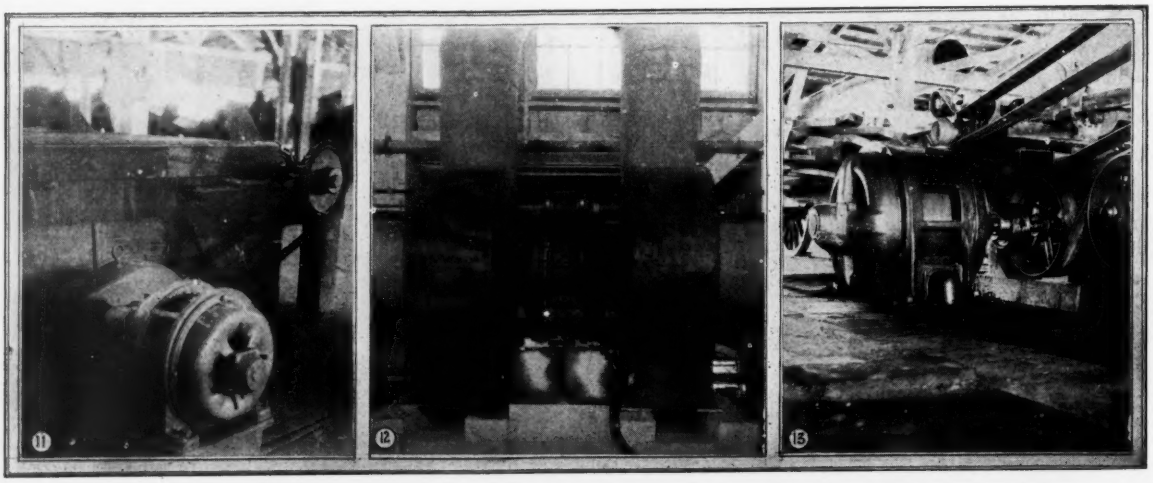


FIG. 11. REDUCTION GEAR UNIT DRIVING FLOORING SORTING TABLE. FIG. 12. INTERESTING APPLICATION OF A MOTOR DRIVING TWIN FANS. FIG. 13. ANOTHER INDUSTRIAL MOTOR APPLICATION

Summary of Equipment and Materials Used in Crossett Lumber Co. Plant

Boilers, Superheaters and Furnaces

Make of boilers....Erie City Iron Works
Type....Vertical water tube
Heating surface, each....5009 sq. ft.
Pressure designed for....225 lb.
Number of passes....3
Make of superheaters....Power Specialty Co.
Type....Standard, Foster
Heating surface, each....510 sq. ft.
Superheat at 100 to 200 per cent rating ..47 to 55 deg. F.
Furnace type....Stationary grate, flat arch, steel encased
Grate surface....141.9 sq. ft.
Ratio, grate to heating surface....1 to 35.3
Make of arch....M. H. Detrich Co.
Fuel used....Waste wood ordinarily, oil in emergency
Make of oil burning equipment....Schutte-Koerting Co.
Fire brick furnished by—Laclede-Christy Clay Products Co. and Evans & Howard Fire Brick Co.

Boiler Accessories

Soot Blowers....Vulcan Soot Cleaner Co.
Feed water regulators....Northern Equipment Co.
Feed valves....Lunkenheimer Co.
Blow-off valves....Lunkenheimer Co.
Blow-off cock....Lunkenheimer Co.
Safety valves....Reading Steel Casting Co.
Steam gages....Manning, Maxwell & Moore Co.
Whistle....American Brass Co.
Instruments
Feed water temperature recorder....Foxboro Co.
Range....50 to 200 deg. F.
Steam pressure recorder....Foxboro Co
Range....5 to 250 lb.

Fuel Handling and Miscellaneous Boiler Room Equipment

Chain conveyors....Weller Mfg. Co.
Belt conveyor....Stearns Conveyor Co.
Chimney, builder....Weber Chimney Co.
Material....Reinforced concrete
Dimensions....275 ft. high by 20 ft. dia. at base
High pressure dust system....Allington & Curtis Mfg. Co.
Low pressure dust system....Shreveport Blowpipe & Sheet Iron Works
Blowers....P. H. & F. M. Roots Co.
Feed water heaters....2-2000 hp. Cochrane Corp.
Service pumps....Worthington Pump & Mach. Corp.
1-3 in. centrifugal driven by a 20 hp. Westinghouse turbine.
1-4 in. centrifugal driven by a 20 hp. General Electric Co. 440 v. induction motor.
Boiler Feed Pumps, make....Manistee Iron Works
Number....2
Capacity....275 gal. per min. each
Head....630 ft.
Drive....2—80 hp. 2800 r.p.m. Terry steam turbines

Turbo Generators and Switch Gear

Make....3—General Electric Co.
Rating....1500 kw. at 80% p. f.
Speed....3600 r.p.m.
Steam rate at full load....17.1 lb. per kw. hr.
Make....1—Allis Chalmers Co.
Rating....750 kw. at 80% p. f.
Speed....3600 r.p.m.
Steam rate at full load....18.7 lb. per kw. hr.
Voltage....480
Exciters....Direct connected, 125 v.
Steam pressure....200 lb. at throttle
Superheat....50 deg. F.
Vacuum....26 in. mercury
Switchgear-make....General Electric Co.
Type....Truck type
Synchronous condenser..General Elec. Co., 750 kva. capacity

Condensers

Make....C. H. Wheeler Mfg. Co.
Type....Surface
Surface for 1500 kw. unit....3260 sq. ft.
Surface for 750 kw. unit....1430 sq. ft.
Tube, dia....1 in.
Tube guage....No. 181 B. W. G.
Tube material....Admiralty metal
Number of passes....4
Guarantee based on....85 deg. F. water and 3 in. absol. vacuum
Gal. water per hr. for 1500 kw. unit....3000
Gal. water per hour. for 750 kw. unit....1600

Air Pumps

Make....Radojet, C. H. Wheeler Mfg. Co.
Number per condenser....2
Steam pressure....135 lb. ga.

Hot Well Pumps

	1500 kw. unit	750 kw. unit
Make	C. H. Wheeler Mfg. Co.	
Size	2 in.	1½ in.
Total head	30 ft.	30 ft.
Drive	5 hp. 3600 r.p.m. Terry turbine	3 hp. 3600 r.p.m. Terry turbine

After Condensers

Make....C. H. Wheeler Mfg. Co.
Type....Surface

Circulating Water Pumps

	1500 kw. unit	750 kw. unit
Make	C. H. Wheeler Mfg. Co.	
Capacity	3000 gal. per min.	1600 gal. per min.
Total head	45 ft.	45 ft.
Drive	50 hp. Allis-Chalmers induction motor	25 hp. Allis-Chalmers induction motor

Miscellaneous Equipment

Reduction gears..Foote Bros. Gear & Mach. Co., Falk Corp.
Crane....Whiting Corp. 10 T.
Oil Filter, make....Wayne Oil Tank & Pump Co.
Type....Continuous flow
Air Compressors, make..Worthington Pump & Mach. Corp.
1—9/17 by 15/19½ by 12 in.
1—9 by 10 by 10 in.
Air receiver, make....Worthington Pump & Mach. Corp.
Size....4 ft. by 12 ft.
City water pumps....1—Worthington Pump & Mach. Corp. 5 in. driven by General Elec. Co., 25 hp. induction motor.
1—The American Well Works, 500 g.p.m. 125 ft. hd. driven by a 25 hp. General Elec. Co. induction motor.
Fire pumps....1—Worthington Pump & Mach. Corp.
Size....20 by 12 by 16 in.
1—Prescott, size....20 by 12 by 12 in.
Piping, high pressure steam, fabricated and erected by....Pittsburgh Piping & Equipment Co.
Pipe, furnished by....National Tube Co.
Flanges....Rolled Steel Van Stone
Gaskets....Hard fibre asbestos
Low pressure steam, fabricated and erected by....Pittsburgh Piping & Equipment Co.
Pipe, furnished by....National Tube Co.
Flanges....Cast iron screwed
Gaskets....Cloth inserted rubber
Underground water pipe....American Cast Iron Pipe Co.
Atmospheric exhaust pipe....American Spiral Pipe Co.
Circulating water pipe....Straight riveted
Flanges....Steel

Valves

Gate....Crane Co.
Stop and check....Edward Valve & Mfg. Co.
Reducing....Foster Engineering Co.
Globe....Lunkenheimer Co.
Pipe insulation....Armstrong Cork & Insulation Co.

Building Construction

Building steel....American Bridge Co.
Roofing tile....Federal Cement Tile Co.
Steel sash....Detroit Steel Products Co.
Walkway grating....Irving Iron Works Co.
Glass....Pittsburgh Plate Glass Co.
Roller doors....Kennier Mfg. Co.

the stack the header consists of a large vertical expansion bend. The turbine leads are taken off at points along the header opposite the turbines. At the west end leads go to the hardwood mill, garage and shops and at the east end the two saw mills and kilns are supplied. The town heating line is taken off at the east end. This line is of 4-in. pipe encased in Non-pareil pipe covering. It is supported on wood bents 20 ft. high and 40 ft. apart. This line is more than a mile in length and only five expansion bends are used because every advantage was taken of the necessary corners. The total lengthwise expansion is 14 ft. Provisions for future service are made at both ends of the header.

Outside the turbine room, about 7 ft. from the east wall is a structural steel rack, 44 ft. high, 12 ft. wide and 39 ft. long. On this the power lines are dead-ended and taps brought up to them from the switches in the power house.

System of Handling Fuel

One of the most interesting problems of the whole job and the one which justified the most exhaustive study from

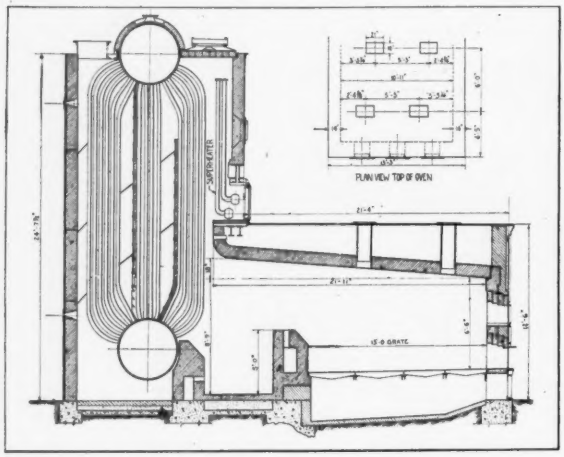


FIG. 14. SECTIONAL DRAWING OF THE WASTE WOOD BURNING FURNACE AND BOILER SETTING

every angle, was the devising and construction of arrangements for fuel handling and storage. Nearly every lumber producing company in the country emphasizes its originality by having a distinctive fuel system. The fuel house at Crossett is the result of an extensive study of the problem of wood refuse storage. The design of this fuel house was evolved after much study of the behavior of the mixture of hog fuel, sawdust, and shavings. At times it is actually self-supporting over a long, flat arch; at other times it is granular, like a pile of wheat and again, it will act much the same as a similar body of water. The extremes of all these conditions had to be considered in the design of the Crossett fuel house. The fuel burned at this plant consists of shavings, which contain about 5 per cent moisture; saw dust, which contains about 44 per cent moisture and hog fuel, which contains about 46 per cent moisture. The mixture of these three fuels averages about 8500 B.t.u. per lb. as fired.

Fuel storage for use in the boiler furnaces is taken care of by the fuel house, which is 18 ft. to the south of and parallel to the boiler room. It is 160 ft. long, 36 ft. wide and 42 ft. from the floor to the bottom chords of the roof trusses. The roof is cement tile laid on the trusses, which in turn are carried on the wall columns that are spaced 16 ft. apart. A 12-ft. monitor runs the entire length of the building and is reached by a stair at the east end.

Due to the possible extreme load conditions, the walls, which are of reinforced concrete, are 12 in. thick at the bottom and 6 in. thick at the top. The steel wall columns are composed of plates and angles and are 4 ft. 6 in. deep at the bottom and 9 in. deep at the top. The inside flange-angles of the columns are vertical and were punched in the shop to fit the spacing of the wall reinforcing rods. This made possible the fastening of the wall rods to the columns in positive spacing and eliminated the wiring of the rods to the forms for the concrete. The steel wall columns were entirely encased in concrete, thus forming reinforced buttresses.

Pouring a concrete wall 42 ft. high with an average thickness of 9 in. is a considerable chore. It was accomplished by making the forms in sections on the ground and hoisting them into position. The forms were made of 2 by 6-in. tongue and groove pine laid horizontally with 3 by 5-in. hard oak stiffeners every 2½ ft. After erection, 4 by 6-in. whalers were carried horizontally along the forms so that they did not bulge in any way. The forms were built in sections 16 ft. long and 10 ft. 6 in. high, thus making four sections to the complete height of the wall.

Enough forms for three bays on two walls were made. The north and south walls of the building were carried up simultaneously, one section on each side. After the bottom sections were poured the next sections were raised. As the concrete set, the forms were removed and erected in other bays. It worked out that as the top section was being poured in any one bay the bottom section was being removed and erected in a new position.

Scaffolding Was Not Necessary

One of the big advantages of this method was that no scaffolding was required. The forms were fastened to the steel wall columns and spaced with blocks and bolts. The pouring was all done from the monitor of the building. An elevator with two mixers was erected at a point 20 ft. west of the building. The dump cars were taken off the elevator and rolled along the monitor to a hopper opposite the forms to be poured. From these hoppers the concrete was led in spouts to the forms.

Great care had to be taken to see that the concrete was well tamped. After the forms were all removed the entire building was rubbed with carborundum stone and water, thus giving it an exceptionally fine sand finish. No expansion joints were used in the construction of this building and although it has been filled to capacity several times at this writing, no cracks, separation, or defects of any kind have shown up.

In order to get the fuel from the mills to the fuel house, a high pressure blower system is used. At each of the planer mills a charger house was erected. These houses are about 25 ft. square and on top of each is located a large cyclone collector. The collector receives the shavings from the machines through two low pressure lines 30 in. in dia. and feeds them down into the charger. The charger is merely a revolving cylinder, divided into five radial compartments and connected to a high pressure blower. As each compartment passes under the spout from the

collector, it is filled and the charge is blown out as the compartment passes over the high pressure discharge port. The high pressure line is 12 in. in diameter. The charge passes through this line at the rate of 6000 ft. per min. The sawdust and hog fuel from the saw mills is fed directly into the chargers from conveyors.

Three Collectors Are Located at the Fuel House

Fuel lines are supported overhead and reach the east end of the fuel house about 30 ft. from the ground. Switches are provided in the lines at this point so that the fuel may be diverted past the fuel house to a burner. The line to the fuel house, after leaving the switches, rises vertically to a height of 80 ft. to three collectors supported on a steel tower on top of the fuel house. These collectors feed down to a 36-in. belt conveyor which runs the full length of the monitor. The fuel is plowed off the conveyor at six points and it falls into the bins.

In order to prevent any tendency of the fuel to arch over in the bins, each bin is equipped with a loose chain extending down almost to the bottom and operated by a sprocket on a shaft below and parallel to the conveyor. These fuel bins are V-shaped pockets with the bottom of each V opposite a boiler in the boiler room. The entire bin structure is supported on timber framing and is wholly independent of the fuel house structure. The bottoms of

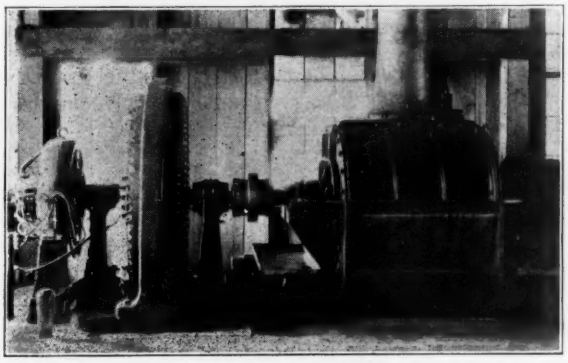


FIG. 15. SYNCHRONOUS MOTOR DRIVING SOOT BLOWER ON HIGH PRESSURE FUEL DISTRIBUTION SYSTEM

the bins slope up towards the boiler house and have a system of ratchet operated gates on one side.

These gates feed onto trough chain conveyors which run to a point about 15 ft. above the firing deck in the boiler room and discharge into the hoppers from which the fuel is distributed to the four down spouts through which the furnaces are fed. The depth of the fuel bed in the furnace is about 30 in., and without taxing the system in any way the boilers can be operated easily at 250 per cent of rating. A significant feature of the fuel handling system is that without any manual effort the entire contents of the fuel house may be delivered through one boiler spout. This condition reduced the otherwise costly fuel handling problem to a simple matter of motor control.

One feature of this installation which should be given particular attention is that of the design and proportions of the furnace. As previously stated, the fuel is fed in from the top and drops upon stationary grates which are 13 ft. long by about 12 ft. wide. The height of the furnace at the front end is 6 ft. 6 in.

At the rear end of the grate is a hollow bridge wall through which air may be admitted if it is found necessary. Back of this bridge wall is a combustion chamber which is 7 ft. deep. In front of the lower drum of each boiler is a second hollow bridge wall through which additional air for combustion may be admitted should it be required.

Boilers and Furnaces Are Encased in Steel

Each boiler has 5009 sq. ft. of heating surface. The ratio of grate surface to heating surface is 1 to 35.3. Each boiler and furnace is set singly and is encased in a steel casing. The baffles are arranged for three gas passes through the boiler. This setting has proven that the fuel can be completely and economically burned within the furnace so that no cinders have to be removed from the base of the

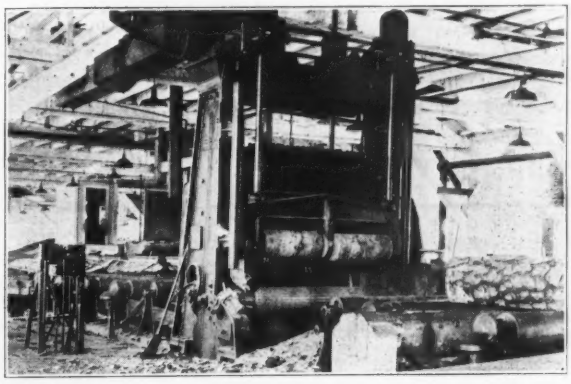


FIG. 16. GANG SAW WHICH IS DRIVEN BY A 400-HP. SLIP RING MOTOR

stack, nor is there any danger of lumber damage by stack discharge as a result of incomplete furnace combustion.

Seventeen miles from Crossett the lumber company owns valuable oil and gas property. Therefore, as an insurance against the probability of a shut down due to lack of wood fuel, arrangements have been made whereby the boilers can be fired with either oil or gas. Just in front of the boiler furnaces a covered trench has been constructed in which oil pipes have been laid. At the present time oil burning equipment has been provided for but three of the furnaces.

Feed water is not treated. It is taken directly from a pond and pumped into an overhead service tank, the capacity of which is 125,000 gal. The feed water pumps draw their supply from this service line and discharge it directly into the boilers.

Before all the power units were centralized at one place there were 70 men employed whose services were charged against power production. With the new plant in operation, this number has been cut down to 19. The labor about the new plant is distributed as follows on three 8-hr. shifts:

One man on upper boiler deck.
One man on lower boiler deck.
One man at upper conveyor in fuel house.
One man on lower floor in fuel house.
One man in turbine room.
One man in turbine room basement and 1 chief engineer.

Design and construction of the power plant, the electrification of the lumber mills and the distribution of power and steam throughout the town of Crossett were carried out in their entirety by the Sessions Engineering Co., Chicago, Ill.

Brittleness and Cracks in Seams of Steam Boilers

CAUSES AND PREVENTION OF SO-CALLED CAUSTIC EMBRITTLEMENT IS DISCUSSED. BY H. KRIEGSHEIM

PHENOMENA OF cracking in metals resulting from prolonged exposure to internal stress have long been known in the case of brass and are usually referred to as season-cracking. A typical feature of season-cracking is that fracture occurs with little or no plastic deformation and that it is essentially intercrystalline in character.

Analogous phenomena have been found in other metals, as for instance, in steel plates of steam boilers, where sometimes brittleness or intercrystalline cracking is found in or near the riveted seams. The occurrence of the phenomena in a few isolated exceptional cases in caustic soda concentrators many years ago led to the assumption that chemical action might be an exclusive and necessary cause of the phenomenon and terms such as corrosion cracking and caustic embrittlement have been used to describe this assumption.

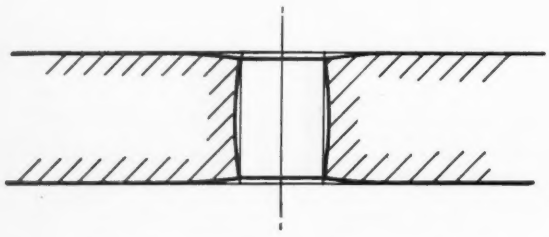


FIG. 1. RIVET TENDS TO ASSUME A BARREL SHAPE

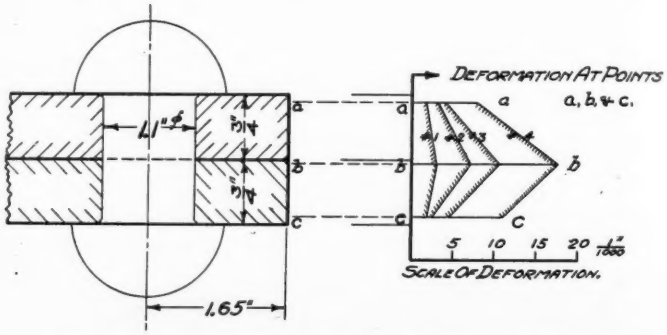


FIG. 2. DEFORMATION OF EDGES OF RIVETED PLATES IS GREATEST AT THE CONTACT SURFACES AND INCREASES WITH THE RIVETING PRESSURES USED

In the meantime, however, it has been definitely established that prolonged stress is the main and necessary cause of the phenomena and that the presence of caustic soda in these cases was merely a coincidence. It is a fallacy to assume that because two things occur simultaneously they must necessarily be cause and effect. Caustic soda occurs in nearly all boilers in greater or less degree, so that in the same way one might blame all boiler troubles on caustic soda. Intercrystalline cracks can be produced in the absence of corrosive agents but are never produced in the absence of stress.

Those who support the caustic embrittlement theory in steam boilers realized that the water inside a steam boiler never contains caustic solutions in sufficient strength to have any effect. They, therefore, constructed a further theory that the caustic solutions concentrates in the seams. Attempts have been made to demonstrate such concentrations in seams but without success. Furthermore, the active embrittling agent supposed to be released from the caustic soda is hydrogen and Fuller has shown that just as much hydrogen is occluded from ordinary tap water as from caustic soda solutions.

In the case of caustic evaporators, even in those days when little was known about this matter, causes other than caustic soda were sought, when cracks were found in exceptional cases, as is shown by the following abstract from a paper presented by Mr. Syromeyer of the Manchester Steam Users Association before the Iron & Steel Institute in 1907.

"Plate N.—This sample is from a shell plate in the steamspace of a boiler, No. 7, which cracked in use when about four years old, having during the last six months been fed with caustic soda.

"Considerable mystery surrounds this case, for it was at the time believed that the brittleness was due to the caustic soda, yet as far as can be gathered, none of the uninjured plates were tested to ascertain whether they were brittle. The possibility that the fractures were due to straining the plates at a blue heat does not appear to have presented itself at the time but seeing that five out of the 180 shell plates of the boilers fractured and only one furnace ring groove in the usual way, this possibility should not be overlooked.

"At the time that these boilers were built the boiler-works had horizontal shell bending rolls and, as is well known, these rolls leave flats on the ends of the plates, for which reason these ends often receive a preliminary bend with heavy sledge hammers. This bending, as boiler-makers know, is greatly facilitated by laying a heavy red-hot plate across the line of bend but this unfortunately introduces the risk of carrying out the bending action when a narrow zone is blue hot. Now the five injured plates have all cracked just beyond the inner row of rivet holes. Had the injury been caused by the soda, the cracks should have occurred anywhere under water but certainly not as happened in one or perhaps two cases in the steam-space.

"The boiler-works in question also had a cogging riveter which did its work with lightning rapidity. This resulted not only in the laps becoming hot but also in the rivet-head flying off at odd times, even after the boilers were in use. This was a general experience and not confined to the nine boilers in question."

This quotation shows that boilers made under identical conditions, not fed with caustic soda, suffered troubles similar to those encountered in boilers fed with caustic soda. Therefore, the use of the term corrosion cracking or caustic embrittlement is unjustified and should be

abandoned, since it diverts attention from the underlying cause of cracks and creates an erroneous idea of the phenomena.

If brittleness and cracks occur in seams, which is an exception and not the rule, then there are always internal stresses at work, which are due to cold working or improper heat treatment of the material. These internal stresses often far exceed the stresses due to the boiler pressure and since it is difficult to find indications of their presence they may become extremely dangerous. In many cases where failures occurred it has been established that they appeared after additional work had been done; for instance, after repeated recaulking, which caused additional internal stress. Therefore, it is of utmost importance to determine the condition of the material in the seams before they are subjected, in the event of leaks, to additional cold work.

Rosenhein and Hanson of the National Physical Laboratory, in a paper read before The Iron & Steel Institute in 1920, giving the result of an investigation relating to this matter, made this statement:

"In the case of boiler plates no actual determination of the amount of stress existing in the material could be made. The steel as supplied in the form of flat plates was probably free from any internal stresses and even the internal stresses set up by the bending of the plates can hardly be responsible for the failures. In the process of constructing the boiler itself, however, operations are carried out which may easily lead to the establishment of serious internal stresses. During the process of riveting if the edges of the plate do not fit together accurately or if the rivet holes do not register exactly, the sheet is forced into position and held there by the rivets. Further, the action of riveting itself may leave considerable stresses in the material in the immediate neighborhood of the rivet holes, particularly if the pressure employed in closing the rivet has been great. In Case No. III, the material was in some cases seriously depressed under the rivet heads, indentations as much as $\frac{1}{16}$ in. below the general surface of the plate being found. The riveting pressure in such cases has been great and must have left considerable stress both in the material of the plate and in the rivet itself. As it has been proved that corrosive action is not essential to the occurrence of intercrystalline cracking under the prolonged application of stress, this section can only be regarded as a subsidiary and not a fundamental cause of the phenomena."

Referring to the same subject, Mr. Rosenhein before the Faraday Society in 1921, stated the following:

"In the actual case described by Mr. Hanson, which I may say, was not from a Navy boiler, but from the mercantile marine, the cracking, as he emphasized, was much more marked in the external cover plate, which had 4 in. of solid steel between it and the water of the boiler, than it was in the inside butt strap which was exposed to the water and it is difficult to think that it was really chemical action derived from the boiler, or its contents, which had anything to do with the cracking in that case and the same applies to the rivet heads."

Of course, it is impossible to fabricate a boiler, and particularly a seam, without straining the material. However, experience has shown that good material, as required for steam boilers, will not be seriously affected by unavoidable stresses introduced during the manufacture, if brittleness introduced in the edges by shearing the plates is properly removed, if holes are drilled and not punched, if pin drifting, to make holes register, is omitted and if riveting pressures are kept within reasonable limits.

The consequences of high riveting pressures are not, as yet, generally recognized. That they are the main cause of the cracks in rivet holes is proved by the indentations under the rivet heads, which can be found almost without exception in seams in which rivet hole cracks appear. As early as 1893, attention was called to such indentations by S. M. Vauclain of the Baldwin Locomotive Works. Mr. Vauclain recommended pressures of 160,000 lb. per sq. in. of rivet holes area and stated that these pressures would cause no visible indentations under the rivet heads, while he had found that the use of higher pressures caused more or less perceptible indentations.

E. W. Rogers of the American Locomotive Co. presented a paper at the Annual Convention of the Master Boiler Makers' Association in 1922 in which he suggested that tests be made to determine the proper pressure for a given size of rivet and plate thickness. He added, "This would seem proper when we consider the possible effect of excess pressure caused by pressing a hot plastic rivet in a hole, which approaches to some extent the action of a hydraulic press. This effect is sometimes apparent by the wavy appearance of the edge of the plate. The remaining effect is the squeezing action on the plates by the riveting dies, tending to raise the edge of the plates from contact with the adjacent one. It is evident, therefore, that excessive riveting pressure, if used to insure tightness, would have the opposite effect, necessitating excessive caulking." He also suggests the consideration of the advisability of using plates of lower tensile strength but of higher ductility, bearing in mind the severe stresses and rough

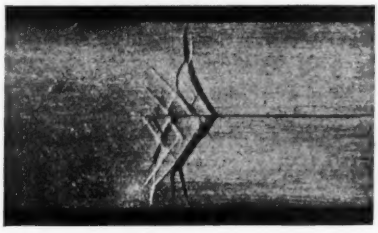


FIG. 3. STRAIN CONFIGURATION AT EDGES OF RIVETED PLATES

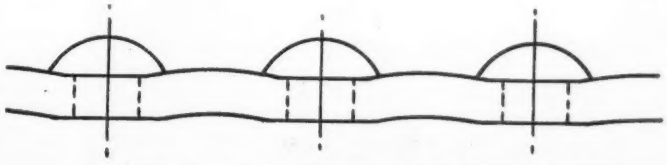


FIG. 4. PLATES TEND TO BULGE BETWEEN RIVETS

FIG. 5. BULGING AND DEFORMATION FOUND IN A RIVETED PLATE

usage to which the plates will be subjected in boiler construction.

Experiments, as suggested by Mr. Rogers, have actually been made by R. Baumann of the Material Testing Laboratory, Stuttgart. They sustain the observations of Mr. Rogers in every respect. Baumann found that the rivets have a tendency to assume the shape of a barrel as in Fig. 1 and that the pressure exerted by the rivet upon the walls of the rivet hole is great enough to produce measurable permanent deformation of the plates.

This tendency of the rivet to assume a barrel shape causes the greatest internal stresses where the plates make contact, as shown in Fig. 2, and that is why cracks in seams generally start in the contact surfaces around the rivet hole and are not visible from the outside. These incipient cracks may be present when the boiler leaves the shop and the cracks only work their way through the

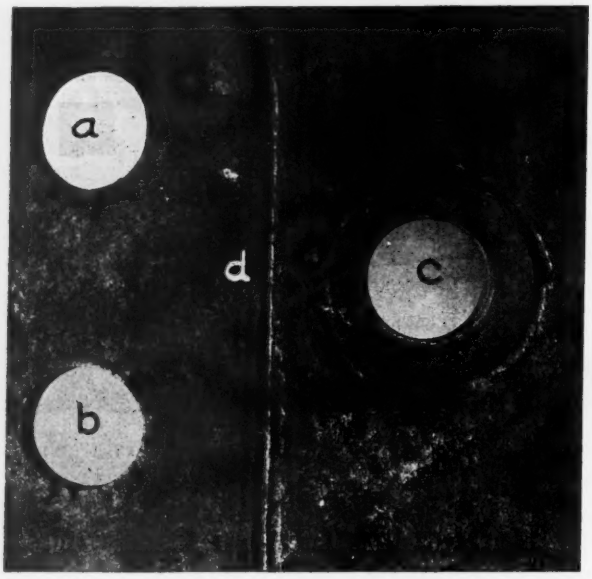


FIG. 6. BOILER PLATE WITH OUTER STRAP REMOVED. CRACKS IN CONTACT SURFACE ARE SHOWN AROUND THE RIVET HOLES A AND B, INDENTATION UNDER RIVET HEAD IS SHOWN AT C. FURROW IN PLATE CAUSED BY CAULKING OF EDGE OF BUTT STRAP IS SHOWN AT D.

plate from the contact surfaces outward on the application of additional thermal and tensile operating stresses. Strain configurations obtained by etching the surfaces revealed that the greatest internal stresses were introduced into the plates around the rivet holes where the two plates, connected by the rivets, meet. This action is shown in Fig. 3 and around the holes "a" and "b" in Fig. 6. This is exactly the location where most of the rivet hole cracks are found when seams are examined which failed in operation.

Another source of deformation of the plates is the pressure exerted upon the rivet heads, which if great enough to produce indentations under the rivet heads, will cause additional internal stresses in the plates by deforming them and crushing the material around the rivet hole, as shown in Figs. 4 and 5. The result is, as Mr. Rogers pointed out, that excessive caulking is then necessary to make such joints tight, whereby additional internal stresses are introduced. Later on, during operation, the seam is subjected to heat by which additional stress is added and besides it has to withstand the working stress, caused by the pressure within the boiler.

If rivets are removed from seams which cannot be kept tight or which required repeated caulking, it invariably is found that the plates are warped and that the edges have been raised from contact an appreciable distance, in some cases about ⅛ in. and even more and deep indentations will be found under the rivet heads. If the rivet holes are cleaned and examined, cracks may be detected in the holes, starting from the points where the two plates meet. These are exactly the conditions which, according to our present knowledge, have to be ascribed to high riveting pressures. Baumann, therefore, made further experiments and determined the riveting pressures which are necessary to upset the rivets to fill the holes completely. He found that there is no need to use higher pressures than approximately 120,000 lb. per sq. in. of rivet hole area and that seams fabricated in this manner will not be subjected to dangerously high internal stresses. The pressure found by Baumann is lower than the pressure recommended by Vauclain in the year 1893. However, it must be considered that the holes in the plates with which Mr. Vauclain experimented were punched, while Baumann experimented with drilled holes. The punched holes, of course, required higher pressures to upset the rivet, due to their rough surfaces.

Baumann also measured the temperatures to which the material of the plate is raised around the rivet holes during riveting and found that temperatures between 500 and 900 deg. F. are easily reached; that is, the range of the so-called blue-heat at which mild steel is sensitive, if subjected to plastic deformation.

Mr. Stromeyer in 1907 called attention to the high temperature to which seams may be heated during riveting and the consequences thereof. Pressures which produce indentations under the rivet heads will seriously affect the material at blue heat.

The proposed A. S. M. E. Boiler Code—Rules for the Inspection of Material in Boilers—suggests that if there is any evidence of leakage or other distress in the longitudinal or straight seam of a lap-joint boiler, it shall be thoroughly investigated and if necessary rivets removed or the plates slotted in order to determine whether cracks exist in the seam.

This suggestion should not be restricted to lap-joint seams, but should be applied to every seam which cannot be kept tight or in which leaks extend over a large area. The usefulness of such examinations is best shown by the experience of Mr. Loch, manager of a large boiler shop abroad, who had to contend with the problem of leaky seams, one of which failed, in boilers manufactured during the war when shop supervision was bad. From a large number of boilers manufactured during that period, rivets were taken out and the seams examined. The manufacturer originally assumed it impossible to reduce the riveting pressure previously used but after trying it out he found that it was to his own benefit to do so. In order to avoid troubles of this kind in the future, control apparatuses were connected to the hydraulic riveters which

indicated and registered the pressures used. Mr. Loch concluded his paper as follows:

"No matter how lamentable the boiler troubles experienced in the last three years have been, they have also resulted in a lot of good. All of us have been able to learn much from this experience. These accidents are the cause of the greater attention that is now being given the production of the boiler material, the shop work and the workmanship and the operation of the boiler. If all those concerned and interested in the matter keep on doing their best along the line of co-operation there is no doubt but that a repetition of accidents previously experienced need not be feared."

If all seams which cannot be kept tight or in which leaks extend over large areas are examined, as suggested in the A. S. M. E. Boiler Code, by experts and the attention of boiler inspectors and inspectors of insurance companies is called to these leaks, before the seams are subjected to repeated or injudicious caulking, then the presence of internal stresses will be detected before serious cracks result. These examinations will also demonstrate that the fundamental and necessary cause of brittleness and cracks in seams is internal stress rather than chemical action and that the use of the term caustic embrittlement for the phenomena in question is unjustified and misleading.

Purchasing Power Plant Equipment

Specifications Must Be Complete and Definite. Bids Must Be Brought to a Comparative Basis Analysis

PURCHASE OF power-plant equipment and supplies involves first of all securing the right article. To do this it is necessary that the purchaser has a good working knowledge of the intended use of the article, that he knows the source of supply and that he understands in some measure the process of manufacture of the article which he intends purchasing.

Price is an important item in any buying transaction; it must not, however, be considered until the right article or equipment suitable for the work to be performed has been settled upon. It is no doubt possible to buy a gate or globe valve at a lower price than must be paid for a good blowoff valve. If the latter were the article required it would be a waste of time, money and effort to buy either of the first two types of valves mentioned.

Price enters into consideration after it has been determined where and under what circumstances the article will be used. It would be waste of money to buy an enclosed motor for a factory building where there was no great amount of dust, moisture or acid fumes. The open type of motor at a lower price should be the one selected.

When purchasing is done by the engineer in charge of work, it is reasonable to assume that he has a knowledge of the intended use of the article or equipment. It is seldom, however, that the engineer is the purchaser, for in most large concerns the actual buying is placed with a purchasing agent, who may or may not understand the true conditions and will therefore be inclined to buy on price. The only solution for this condition is for the engineer accurately to specify his requirements and carefully to scrutinize all bids that are received.

Specifications Must Be Accurate and Complete

One practice which tends towards price buying is when a company will pay its purchasing agent a bonus at the end of the year based upon the computed savings which he has made on purchases during that year. Such a scheme is virtually adopting a method by which they defeat their own purpose, because it greatly strengthens the incentive for buying on price as the chief consideration.

When buying must be accomplished through a purchasing agent, the engineer must see that his specifications are clear and definite and that they include such information that both the purchasing agent and the bidder will know exactly what is required. When an engineer writes a specification he is taking the first step in making a purchase. He absolutely must know all the requirements to be met and he must know how to express those requirements so that he can get just the thing which he requires.

Knowing the source of supply is extremely important in practically all purchases. Take, for example, the purchase of centrifugal pumps. There are manufacturers who specialize in horizontal centrifugal pumps, those who specialize in direct acting pumps and again, there are those who specialize only in vertical shaft sump pumps. It is obvious that requests to bid on a centrifugal boiler feed pump should go to those manufacturers in the first class.

It will often be found that one or two quotations will be higher than the others. When this occurs an exacting study must be made of each bid to find out what extra or worth while improvements were included in the higher bids. It simply becomes a question of whether or not the lower bids meet the specifications, or do not contain extras. After that the higher bids can be considered, provided they offer advantages which may not have been foreseen at the time of writing the specifications.

It sometimes happens that one bidder will purposely include some extra or some specialty which it is immediately evident will prove a decided advantage. In this event it would be no more than fair to all concerned to rewrite the specifications and call for the extra, thus giving all bidders an opportunity to submit their propositions on an equal basis.

Time of delivery is a consideration which often causes a great deal of trouble. In the first place each bidder should be made to understand that he will be held to the time which he promises. On a rush job the highest bidder promising immediate delivery might readily be given the contract. On the other hand, the purchaser may readily accept a long delivery knowing that he will not need the equipment until a later date. By the longer period of delivery the purchaser can take advantage of the discount and still have on hand the amount of the bill until a later date.

Discounts can be taken advantage of and better deliveries made and capital expense well distributed if large and expensive units such as boilers are ordered delivered as

they will actually be required in construction. For instance, if five boilers are to be erected, there is actually a loss if the complete order is shipped at one time and it would no doubt delay shipment. An order of this kind should be placed for the first unit within a stated number of weeks and an additional unit every so many weeks until the order is completed.

Manufacturers of steel, casting and tubes often ask for bids two ways, one bid to cover all material and workmanship and the other bid to cover all workmanship and only such material as is not manufactured by the purchaser.

Another point which is important in getting all bids to a common basis is to insist that the prices quoted either do or do not include freight charges. In order to compare the cost of equipment in the various bids it is probably best to ask that the freight charges be stated as a separate item.

Most companies require that on all orders of any consequence at least three competitive bids be obtained. In the power-plant field it is not unusual to obtain from 6 to 8 or even more bids on a set of specifications. An intelligent selection cannot be made from these bids unless they are known to be based upon the same understanding of what is required. It is impossible for the purchaser to carry in his head the comparative details of each bid. Promise of delivery, weight and price are not sufficient upon which to make a selection. It is therefore advisable to tabulate the bids.

Tabulation of Bids

This tabulation takes its most useful form when the vertical columns are headed with the names of the concerns bidding. In the first column at the left should be listed all the important items with which it is desired to compare one bid with another. The left-hand column should start out something like this: Name of bidder, date of bid, price quoted, allowance for freight, weight, and then may follow the specific items which will completely describe the equipment.

Since the specifications should contain all the important points to be covered, it might be said that the first column to the left is virtually an abbreviated statement of the specifications.

It is good practice in a tabulation of bids to show what was specified. For instance, the first column to the left would contain the item, "rated horsepower to each boiler." The next column, headed "specifications," would show the rated horsepower which was asked for by the purchaser. The following columns would then show the ratings which the various bidders contemplate furnishing.

Specifications are man-made and are therefore subject to omission at times. Then again, it is almost impossible for anybody to keep posted on the details of all power-plant equipment development. It is therefore advisable to encourage bidders to submit alternative bids as well as to cover in their main bid the original specifications. These alternative bids should be carefully considered for often they present new ideas which are useful and which will save on the cost of the equipment. This is a most useful way of getting the expert advice of the manufacturer.

At times an alternative bid will change completely the whole problem so that it will be advisable to reject all previous bids and write new specifications, thus giving other manufacturers a new and equal chance at the prospective business.

Use of the Catalog File

Catalogs are useful for at least three good reasons. First, they are excellent guides when writing specifications; second, they are of immeasurable value in studying equipment for the selection of bidders, and third, they describe and show catalog numbers and lists of parts of equipment which is in use and upon which service will at some time be required.

This material accumulates rapidly and unless some definite system is put into immediate use it is not long before the catalog file is an absolute nuisance rather than a valuable aid to the purchaser. One method of filing catalogs which has proven successful is to use sectional bookcases for those books and pamphlets which are stiff. Leaflets may be filed in sectional letter files. This system is flexible and can be expanded as requirements demand.

Due to the broad range of some catalogs it is preferable to file them by the manufacturer's name and then cross-index them both as to manufacturer's name and the products described. Probably once a year it will be expedient to weed out the files, throwing away obsolete literature and those on which there may be duplicates.

Catalogs of equipment which has been installed should be given a special mark in addition to the file number. The file clerk will then understand that those catalogs so marked do not become obsolete, even though they may be old.

Sharp or dishonest practices in purchasing do not pay. Bids are confidential and should not be used so that one bidder will know what his competitor has submitted. Sharp methods by which a lower price may be obtained merely tend to mark the purchaser so that at the next opportunity the bidder will protect himself by adding to his price the amount which he feels he will be expected to cut. One point often overlooked is that manufacturers' sales representatives will gossip. Therefore, you quickly become a marked man in all allied lines if your dealings are not straightforward and honest at all times.

Finally, it must be remembered that any advantage resulting from the placing of an order must revert in full to the company making the purchase. It does not belong to the individual.

An investigation of the explosion hazards in industrial plants using pulverized coal as fuel, which has been conducted by the Department of the Interior, through the Bureau of Mines, for the past several years, has been completed. Practically all the important plants using such fuel were visited, and the installations closely studied for safety conditions and the means employed for eliminating possible hazards. In some plants the Bureau of Mines engineer was able to point out dangerous conditions, and practical changes for their abatement. The results of this research show that the causes of an explosion hazard are similar to those from coal dust in mines. Means of combating them are to prevent clouds of coal dust from getting into the air, and to eliminate possible sources of ignition. A report giving the result of this investigation will be issued by the Bureau of Mines within the next few months.

Characteristic Curves of Steam Turbines

UNDERSTANDING OF FUNDAMENTALS AND FACTORY TEST CURVES WILL ENABLE ONE TO FIGURE EFFECTS OF CHANGED OPERATING CONDITIONS. BY J. Y. DAHLSTRAND*

THIS ARTICLE and the curves which accompany it will serve to illustrate to engineers in general certain main characteristics common to steam turbines. While particularly dealing with turbines in sizes below 700 hp., these characteristics apply equally well to any size turbine and also in general to any type of impulse turbine. A thorough knowledge of these characteristics is important for a proper understanding of the capabilities and limitations of a given turbine under varying conditions. With respect to the relations between steam conditions, power, speed, standing, torque, etc., the steam turbine is different from any other prime mover.

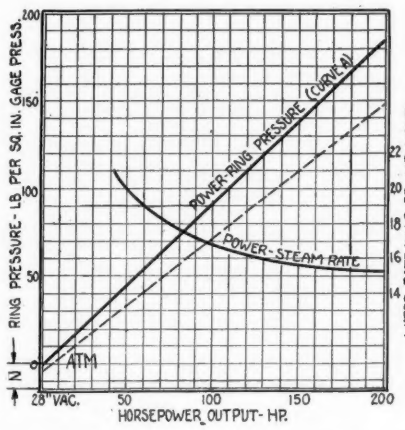

RING PRESSURE - LB. PER SQ. IN. GAGE PRESS.
WATER RATE IN LB. PR. H.P. HOUR
POWER-RING PRESSURE (CURVE A)
POWER-STEAM RATE
ATM.
28" VAC.
HORSEPOWER OUTPUT - H.P.

FIG. 1. CURVE SHOWING RELATION BETWEEN RING PRESSURE AND HORSEPOWER DEVELOPED

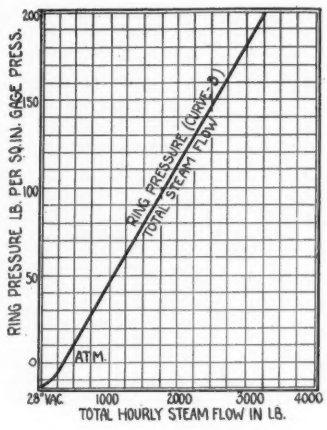


FIG. 2. CURVE SHOWING RELATION BETWEEN RING PRESSURE AND STEAM FLOW

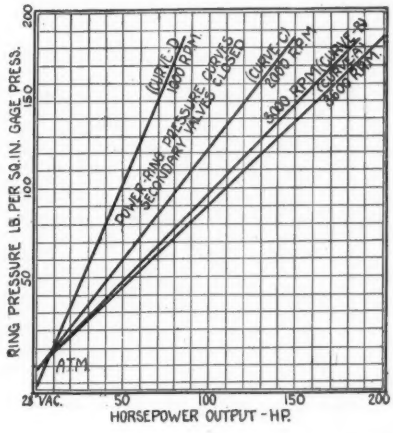


FIG. 3. POWER AND RING PRESSURES AT VARYING OPERATING SPEEDS

In general, if a few points in connection with the performance of a turbine have been determined in a factory test, it should be relatively easy for an engineer to solve within practical limits, the following problems: (1) Power which can be expected with decreased or increased steam pressure. (2) Power which can be expected with increased or decreased back pressure. (3) Effect of superheat. (4) Power and steam consumption to be expected at varied speeds. (5) Steam consumption when the turbine is operating at a partial load. (6) What power the turbine is developing at any moment by observing the ring pressure gage on the turbine, and (7) The total steam flow through the turbine at any moment by observation of the ring pressure gage.

Curves shown in Figs. 1, 2, 3, 4 and 5 represent the performance of a steam turbine of the condensing type with one velocity stage and six pressure stages. It would be as shown in Fig. 7. The normal operating conditions for this turbine would be 200 lb. steam pressure, dry and saturated steam, 28 in. vacuum, 200 hp. normal output and 3600 r.p.m. normal speed.

*Mechanical Engineer, Standard Turbine Co.

EXPLANATION OF RING PRESSURE

It will be well to state just what is meant by the term ring pressure. It is the steam pressure in the steam ring or space between the governor value and the first stage nozzles. A study of Fig. 1 will show that the only variables are the ring pressure and the horsepower output. The variables are, steam line pressure, steam temperature and quality, back pressure and the speed.

This curve illustrates the relation between the ring pressure and the horsepower developed. The curve is practically a straight line except at the lowest pressures where it has a tendency to bend towards the origin. The distance N is called the no load pressure and is a measure of the pressure at which the turbine will run light at operating speed.

In the same figure there is shown a dotted line AX, which represents the power developed at the same speed with secondary valves open and consequently with increased steam flow. Under that condition the turbine would naturally operate as a turbine designed with a greater nozzle area. For the sake of simplicity the secondary nozzle condition is left out of the other figures.

CARE MUST BE USED IN MAKING COMPARISONS

When considering test results and making comparisons of power output of a turbine with original test results, it should be noted that when one or more secondary valves of any type are opened, steam flow and power under all speeds is immediately changed as if it had been given greater capacity. Therefore, care must be used to compare only such figures as are based on the same condition of valves closed or open.

The power-steam rate curve of Fig. 1 is plotted through points arrived at by dividing the total steam flow at any ring pressure, from curve S, Fig. 2, by the output in

horsepower at the same pressure from Curve A from Fig. 1. Similar curves can be obtained for other speeds by dividing the same values from curve S by values obtained for other speeds on curves B, C and D, Fig. 3. In this case the constant factors are: steam line pressure, steam line temperature, steam line quality, vacuum and operating speed. The variables are horsepower output and steam rate in pounds per horsepower hour.

This is the best known characteristic curve for steam turbines. At low loads the curve rises as the losses are distributed on a decreased output and through throttling of the steam a smaller amount of steam can be absorbed through expansion in the turbine. While it is impossible to lay down definite rules for relations between steam rate at full loads and part loads, in general the following

Effect of Varying Operating Speeds

In Fig. 3 is plotted a full set of power pressure curves for varying operating speeds. As the operating speed decreases, there is a tendency for the no load pressure to drop. The maximum ring pressure will depend on the pressure drop required over the governor valve. With 200 lb. gage steam line pressure it is proper to figure on a maximum ring pressure of about 185 lb. gage. Ordinarily the nozzles of a turbine are designed for this maximum ring pressure. If the ring pressure is lowered the steam consumption will increase.

In Fig. 4 are shown the speed-power curves which are designated as F, G, H and I. Those curves are drawn by replotting the curves of Fig. 2, using power and speed as coordinates. Each curve represents a given ring pressure,

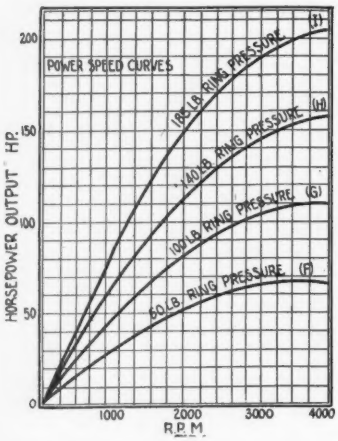


FIG. 4. HORSEPOWER OUTPUT FOR VARYING SPEEDS AND RING PRESSURES

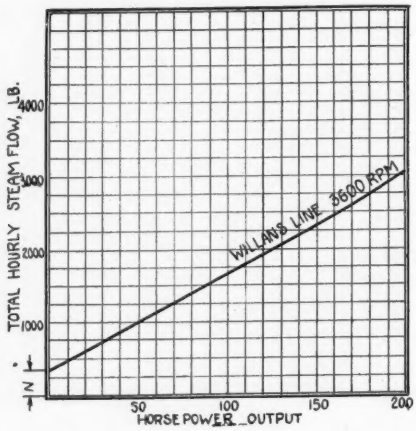


FIG. 5. WILLANS LINE, BASED ON A TURBINE SPEED OF 3600 R.P.M.

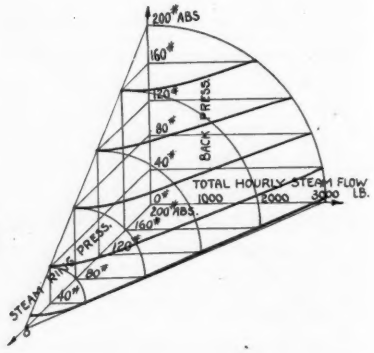


FIG. 6. SOLID COORDINATE SYSTEM, SHOWING RELATION BETWEEN RING PRESSURE AND STEAM FLOW

factors will not be found to be far out of line for any size or type of impulse turbine.

	¼ Load	½ Load	¾ Load	Full Load
Non-condensing turbine	40%	20%	8%	0
Condensing turbine	20%	10%	4%	0

Ring-pressure total-flow curve S of Fig. 2 is drawn through plotted points arrived at through a steam flow test in which was weighed the condensate from the exhaust and at the same average speed and power absorption as for the other curves. The constants are steam line pressure, steam line temperature and vacuum, whereas the variables are ring pressure and steam flow.

This curve illustrates the relation between the ring pressure and the steam flow. It forms one leg of a hyperbola and by means of a solid coordinate system, Fig. 6, with steam pressures, back pressure and steam flow as the three coordinates. It will be found to be the outline of a section through a cone parallel to its axis.

With high back pressure or low steam pressure the section will be taken a greater distance from the center of the cone. The lower end of the curve will have a decided bend. With usual steam pressures and back pressures the section will be close to the center of the cone and the legs of the hyperbola will closely follow its asymptotes, resulting in a line practically straight except at its extreme low point.

hence a given total hourly steam flow. The curves show that the maximum output will be reached at a lower operating speed with a low ring pressure than with a higher one. This will illustrate in a way the necessity of increasing the size of the turbine to obtain maximum efficiency as operating speeds are lowered or steam conditions are bettered.

Willans line, Fig. 5, is arrived at from curves A and S and represents the relation between horsepower output and total hourly steam flow. This curve is a bent line and does not go through origin. The amount of total steam flowing at no load is represented by the distance N. This amount is proportionately higher for non-condensing machines and increases with increased back pressure.

General conclusions which can be drawn from these curves are:

1. Relation between power output and ring pressure approximates closely a straight line.

2. No load pressure will increase with increased operating speed and will also rise with increased back pressure.

3. An increase in steam line pressure on a given turbine with a given output, speed and back pressure will not materially benefit the steam rate of the turbine. The only benefit which will result will be a slight superheating of the steam through throttling. To realize the full benefit from increased steam pressure the nozzle areas should be

reduced to raise the ring pressure to the maximum permissable and by making the nozzle expansion ratios correct for the higher pressures.

4. Steam flow is practically independent of operating speeds with impulse turbines.

In addition to the general rules given, the following will apply with fair accuracy for average conditions:

Power output for a given ring pressure will be influenced but to a small extent by superheating the steam. For a turbine operating condensing there will be no change but for a non-condensing turbine superheat will increase the power output at the rate of 0.3 per cent for each 10 deg. of superheat for the first 150 deg. superheat. The total steam flow at a given ring pressure of a turbine operating condensing or non-condensing, will decrease at an approximate rate of one per cent for each 14 deg. superheat for the first 150 deg. of superheat. As a result of these, the steam rate of a non-condensing machine will decrease one per cent for an average of 10 deg. superheat and the steam consumption of a condensing machine will decrease one per cent for an average of 14 deg. superheat for the first 150 deg. superheat.

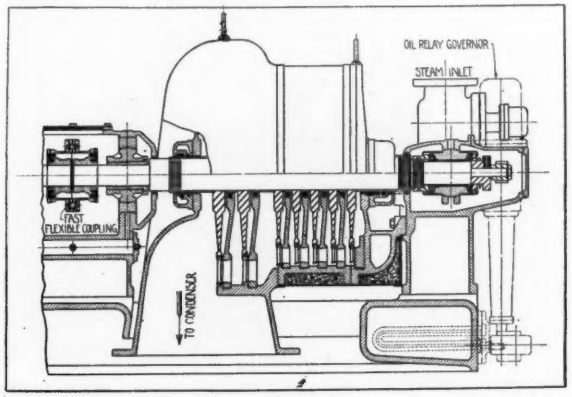


FIG. 7. TURBINE DESIGNED WITH ONE VELOCITY STAGE AND SIX PRESSURE STAGES

Moisture will increase the steam flow for a given ring pressure by as many per cent as the percentage moisture, for qualities above 97 per cent. Moisture will decrease the power for a given ring pressure to about the same extent for the same qualities. In other words, the steam rate will be increased at the rate of 2 per cent for each per cent of moisture for qualities above 97 per cent. For qualities below that figure the effect will not be quite so great.

For steam pressures of 150 lb. or over, small changes in back pressure or vacuum will not appreciably affect the steam flow of impulse turbines. Power and steam rate will be affected in accordance with the percentages given below:

Non-condensing. Power will decrease and steam rates increase on an average by the percentages given for each pound of added back pressure up to 15 lb.

200 lb. steam pressure.....2%
150 lb. steam pressure.....1½%
125 lb. steam pressure.....3%
100 lb. steam pressure.....4%
75 lb. steam pressure.....5%

Condensing. Turbines designed for 28 in. vacuum with steam pressures of about 150 to 200 lb. will increase in steam rate at about the following percentages:

27 in. vacuum.....6%
26 in. vacuum.....11½%
24 in. vacuum.....18½%

At partial loads the increases will be greater.

Steam line pressure will not greatly benefit steam rate unless the ring pressure is also raised to within the proper valve pressure drop. In this latter case the effect of steam line pressure on steam rate is as follows:

Non-condensing—

200 lb. pressure.....minus 50%
175 lb. pressure.....minus 3%
150 lb. pressure.....minus 0%
125 lb. pressure.....plus 5%
100 lb. pressure.....plus 10%
75 lb. pressure.....plus 22%

Condensing—

200 lb. pressure.....minus 2½%
175 lb. pressure.....minus 1½%
150 lb. pressure.....minus 0%
125 lb. pressure.....plus 2½%
100 lb. pressure.....plus 5%
75 lb. pressure.....plus 10%

For the above figures, 150 lb. pressure is taken as normal.

Installation and Care of Chain Drives

OWING to varying conditions, the amount of tension on a chain drive is difficult to prescribe. As a general rule, however, according to the Ramsey Chain Co. this tension should be less than that of a leather belt because a chain does not depend on tension for its tractive power. It is well to arrange for adjustable centers if possible in order to maintain a uniform amount of slack. In cases where there is likely to be considerable fluctuation in speed, irregularity of load and considerable stopping and starting, chain should be run comparatively taut to avoid whip.

With ordinary drives that are not exposed to unusual operating conditions, the silent chain requires only an application of medium consistency cup grease at sufficient intervals to insure proper lubrication. Particular care should be taken that new chains are greased as above but at more frequent intervals until the chains have become sufficiently "run in." Afterwards one lubrication per week should be sufficient.

Like any other piece of machinery, a silent chain drive requires periodical inspection. The points to watch are rigidity of installation, alinement and lubrication. The time spent in such inspection will be fully repaid by increased life and satisfactory operation of the drive. A reasonable amount of care must be taken to keep the chain clean. Accumulation of gummy grease or dirt prevents proper lubrication of working parts. An occasional kerosene or gasoline bath, with fresh clean lubrication, is recommended.

Application of a chain drive is extremely simple for the reason that a wide variation between the centers of the driving and driven shafts is permissible. In operation, it is quiet. It can be run at high speeds, on short centers and under extreme conditions of temperature and moisture. Properly installed, it requires little attention beyond an occasional lubrication.

Self Contained Pulverized Coal Unit

British Development Which Crushes, Separates, Dries and Delivers Pulverized Coal to the Furnace. By C. H. Tupholme

MUCH HAS BEEN said and written on the subject of large pulverized coal plants employing drying and storing systems. It has often been emphasized that these plants are unsuitable for small installations and are therefore not available for those industrial plants which use little power or wish to introduce the pulverized fuel system on a small scale. Consequently the introduction of the self-contained unit, in which the drying and pulverizing are carried on together and in which the powdered fuel is not stored but is produced only as and when required, will go a long way to popularize the use of pulverized coal in small plants. This unit does away with much of the expense and the inconvenience which is often characteristic of the larger systems.

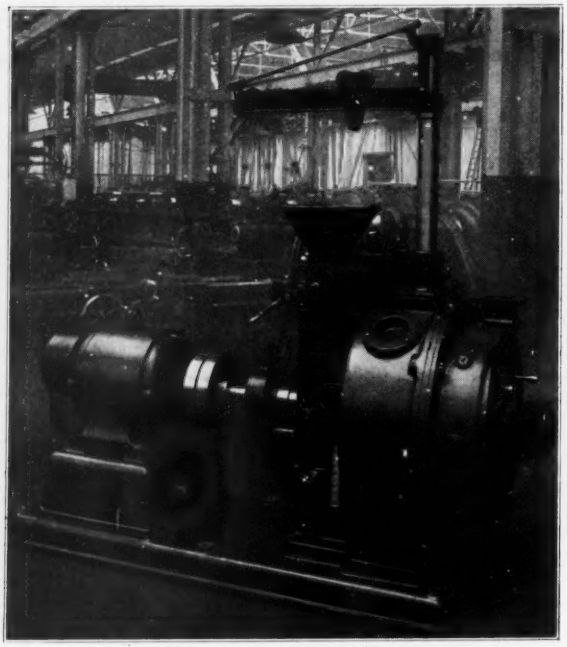


FIG. 1. ASSEMBLED VIEW OF THE SELF-CONTAINED PULVERIZER UNIT

Latest of these self-contained units to be introduced into British power plants is shown in Fig. 1. This unit has the advantage that it requires no auxiliary plant except the means for rotating its spindle and the provision of a supply of raw coal to the hopper. It has also the advantages of low first cost and compactness and at the same time it permits low-grade fuels to be burned economically.

This unit dries, granulates, pulverizes and aerates the coal at one process. From Fig. 2 it will be seen that the body is a casing containing all the working parts. This casing contains a horizontal shaft, which runs on enclosed ball bearings, having upon it a steel disk carrying beaters or pegs on either face. These beaters are arranged to cooperate with similar beaters carried by detachable disk-shaped cheeks on the main frame of the machine. The beaters are short and do not extend the whole way across the casing, the pulverization being effected not so much by the beaters as by the currents of air produced by them, the coal being actually powdered by the impact of the various particles against each other.

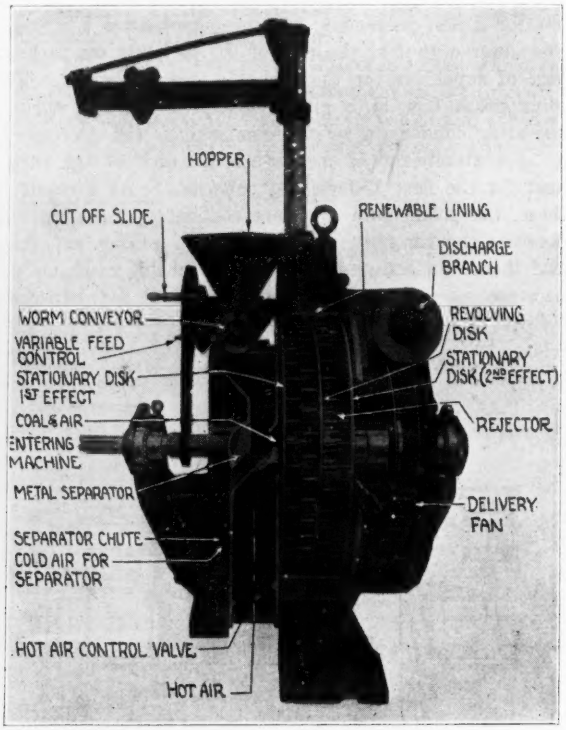


FIG. 2. SECTIONAL VIEW SHOWING REVOLVING DISK, DELIVERY PAN AND REJECTOR

Coal is fed into a hopper, from which it passes by means of a variable screw feed into the separating device. A current of air passes through this separating device in such a direction that it carries the coal into the machine, the heavier pieces of iron, steel or other foreign matter, being too heavy to be lifted by the air current, pass out of the machine through an independent outlet.

Coal enters the unit at the center and passes outward to the circumference through the beaters, then round the edge of the disk and inward toward the center, across the second face of the disk and through the second set of beaters. The first set of beaters is known as the "first effect" and the second set as the "second effect." The path of the coal through the beaters is of a complex nature, as many eddy currents and vortices are formed and are necessary for the proper pulverization and drying of the coal.

Hot air passes into the machine with the coal, first for drying and second for carrying the finely-powdered product into the furnace for combustion. Before leaving the second effect, the mixture of coal and air has to pass through what is called a "rejector fan," which consists of a wheel revolving at the same speed as the spindle of the machine. The effect of this rejector is to throw the heav-

ier particles of coal back into the machine, permitting the passage only of the material fine enough for combustion.

After leaving the rejector, the coal and air passes through a fan which provides the necessary suction through the machine and propels the mixture into the furnace. The wearing parts of this machine are the cast-iron pegs or beaters, which are cheap and can easily be inserted and removed. The main disk of the machine can be taken out and a spare disk inserted when pegs have to be removed, so that a lengthy stoppage is avoided.

Hot air for drying the coal is drawn from the furnace walls or flues and coal containing as much as 25 per cent moisture has been handled satisfactorily. The unit described is manufactured in four sizes, to feed 500, 1200, 2000 and 4000 lb. of pulverized fuel per hour, respectively. The smallest machine is 4 ft. high by 4 ft. 4 in. long by 2 ft. 10 in. wide and weighs about a ton; the largest machine is 5 ft. 8 in. high by 6 ft. 2 in. long by 4 ft. 8 in. wide and weighs just under 4 T. The smallest machine requires 12, and the largest 60 hp. for maximum output.

Effect of Temperature on Metals

REVIEW OF DATA ON IRONS AND STEELS. PRESENTED BEFORE A JOINT MEETING OF THE A. S. M. E. AND THE A. S. T. M.

BEFORE summarizing some of the principal features shown by available data on the properties of metals at various temperatures, attention should be called to the importance of the time factor in mechanical tests of metals at high temperatures. Steel containing 0.81 per cent of carbon was tested at a slow speed which produced rupture in from 5 to 10 min. and also under rapidly applied stresses (in which case the time was from 2 to 8 sec.). Nearly the same strength was displayed whether slowly or rapidly fractured at temperatures below about 600 deg. F., this being a comparatively brittle metal at moderate temperatures. Above this temperature the apparent strength of the rapidly fractured specimens largely exceeded the strength of the others. The higher the temperature the wider apart were the results. An extreme illustration of this kind was furnished by a specimen tested at 1410 deg. F., which ruptured in 2 sec. and showed a tensile strength of about 62,000 lb. per sq. in., whereas at ordinary speed of testing a corresponding bar fractured at 33,240 lb. per sq. in.

Results of tension tests reported by a number of investigators for malleable iron are shown graphically in Fig. 1. There are some indications of a maximum in the tensile strength—temperature curves at about 600 to 800 deg. F. but this is smaller than in the case of carbon steels and for most practical purposes the tensile values may be considered nearly constant throughout the specified range. with further increase in temperature there begins a "softening" which becomes quite rapid above 900 deg. F.

By far the largest number of tests in tension have been made on mechanically worked steels with or without subsequent thermal treatments. Figure 2 shows the effect of temperature variations upon the modulus of elasticity, of carbon and some alloy steels. While an attempt has been made to choose representative results for these graphs it should be kept in mind that they are based on tests of individual heats under specific test conditions.

Some of the important facts, which may be deduced from available results of a large number of similar tests, may be summarized as follows:

1. The effect of temperature rise to about 1100 deg. F. is to reduce tensile strength, proportional limit and the elastic modulus and greatly increase ductility. Certain combinations of composition and treatment, notably normalized chromium-vanadium, quenched-and-tempered stainless and air-cooled 28-per cent nickel steels are strongest at ordinary temperatures but carbon and the majority of alloy steels show maximum tensile strength values and minimum ductility in the range of 400 to 650 deg. F.

2. The drop in strength of steels at temperatures around 1025 deg. F. is permanent for most practical

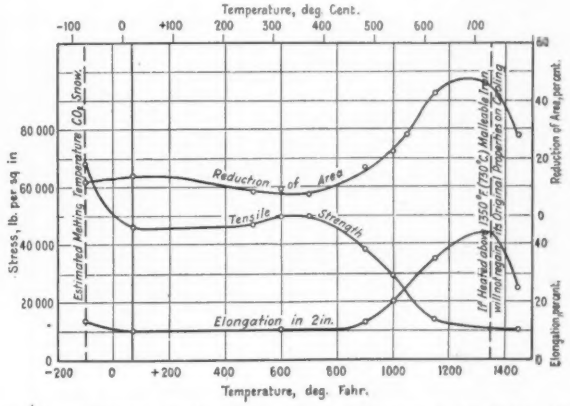


FIG. 1. TENSILE PROPERTIES OF MALLEABLE CAST IRON AT VARIOUS TEMPERATURES

purposes, so that it would appear improbable that commercial steels can be produced to withstand continuously, fairly large loads at temperatures above about 1200 deg. F. except when large proportions of one or more alloying elements are added to reduce the iron content to such a low value that the resulting product cannot correctly be called steel, or in special cases where extremely large proportions of special compounds are present.

EFFECT OF TEMPERATURE ON CAST STEEL

In general, the effect of temperature increase on the mechanical properties of cast steels is similar to that on mechanically worked steels. The actual values obtained in tests will differ materially up to about 800 to 1000 deg. F. and to a somewhat less extent at higher temperatures from those values observed in similar steels after mechanical work. As both chemical and physical characteristics play a predominant part at slightly elevated temperatures in the latter class of steels, so will these same factors, as reflected in the details of casting practice and heat treatment, be of prime importance in determining the properties observed in cast metals. They are, of course, to be considered of importance at all temperatures but the weakening effect on all alloys containing large proportions of iron becomes so marked when the temperature becomes

high that it obscures, at least in large part, the differences referred to. Representative results obtained on cast carbon and nickel-chromium steels are shown graphically in Fig. 3.

Little has been published concerning the torsional properties of ferrous metals at various temperatures. There appears, however, to be a range of minimum ductility in the neighborhood of 400 to 600 deg. F. as shown by the small number of turns (twists) before failure. This coincides quite closely with minimum values of elongation and reduction of area observed in tension tests of similar materials.

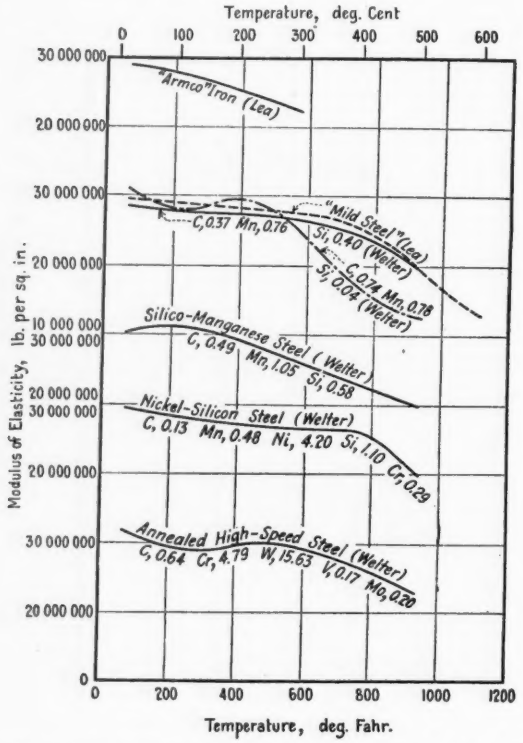


FIG. 2. EFFECT OF TEMPERATURE ON VARIOUS STEELS IN TENSION

Hardness tests show that the hardness decreases progressively with temperature rise from —80 to 2200 deg. F. with the exception of a fairly narrow temperature range around "blue heat" where a rise in temperature results in an increase in hardness. This effect is observed between 400 and 600 deg. F. in the hardness-temperature curves for carbon steels and coincides with the zone of minimum ductility or maximum strength shown in most tension and torsion tests of similar alloys.

Cast irons, as is well known, are subject to permanent changes in volume upon repeated heating and as a result their field of usefulness has been restricted. This effect, which is generally an increase in volume for commercial materials and commonly called "growth," is not only dependent upon temperature and time but also upon composition. White irons shrink and gray irons grow but in white irons containing appreciably more than 3 per cent carbon there is a tendency to deposit temper carbon upon prolonged heating and the metal will then tend to grow. An alloy of practically constant volume under repeated heating at 1650 deg. F. was found to be a white iron containing about 3 per cent of carbon and only small quantities of other constituents and in particular less than 0.2 or 0.3 per cent of silicon.

Carpenter stated that phosphorus tends to diminish "growth" and that if 0.3 per cent is present, growth is lessened by about 3 per cent. The amount of sulphur present in commercial cast irons is not usually sufficient to have more than a minor influence. Manganese is one of the most important elements to be considered and not only retards the rate of growth but in the majority of cases diminishes the absolute amount.

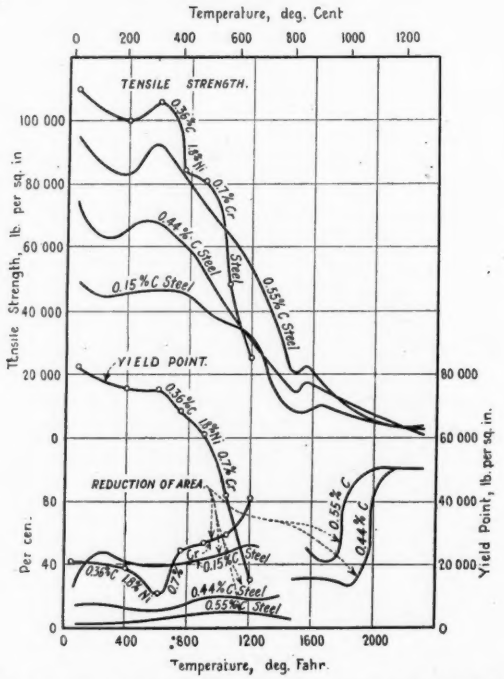


FIG. 3. EFFECT OF TEMPERATURE ON THE TENSILE PROPERTIES OF CAST STEELS

Failures have not been uncommon in iron or steel parts due to intercrystallin attack resulting in what has been called intercrystallin brittleness. Stress, which may be either internal or external but probably restricted in intensity, nature and distribution, is a necessary condition for much selective attack. However, the active agents producing intercrystallin brittleness may vary widely. Thus in power-plant installations the embrittlement of boiler steels may be the result of reactions with dissolved alkaline substances in the feed water.

High-chromium steels present the greatest resistance to scaling at high temperatures of any of the steels. Those of the "stainless" type give a high resistance while those containing about 7 per cent of chromium give a fair resistance though not quite so good as that of the stainless steels. In the latter case, however, the scale is more adherent than in the case of the stainless steel type. The nickel-chromium steels (ordinary structural types) scale to a greater extent than do the steels of any of the other types. Tungsten steels scale comparatively little up to temperatures of about 1560 deg. F., but beyond that they are liable to scale considerably.

The foregoing sketch of available data shows clearly

that irons and steels have serious limitations for high-temperature service. In the case of cast and malleable irons and semi-steels this is further substantiated by the following recommendations of one manufacturer of power-plant equipment:

"Cast iron is recommended for a total temperature of 500 deg. F. when the pressure does not exceed 25 lb. gage and for 100 deg. F. when the gage pressure is not greater than 75 lb. Malleable iron and semi-steels are recommended for temperatures up to 500 deg. F. when the pressure does not exceed 200 lb. gage; at higher temperatures and pressure cast or forged steels are recommended."

Changing Lubricating System on an Old Type Diesel Engine

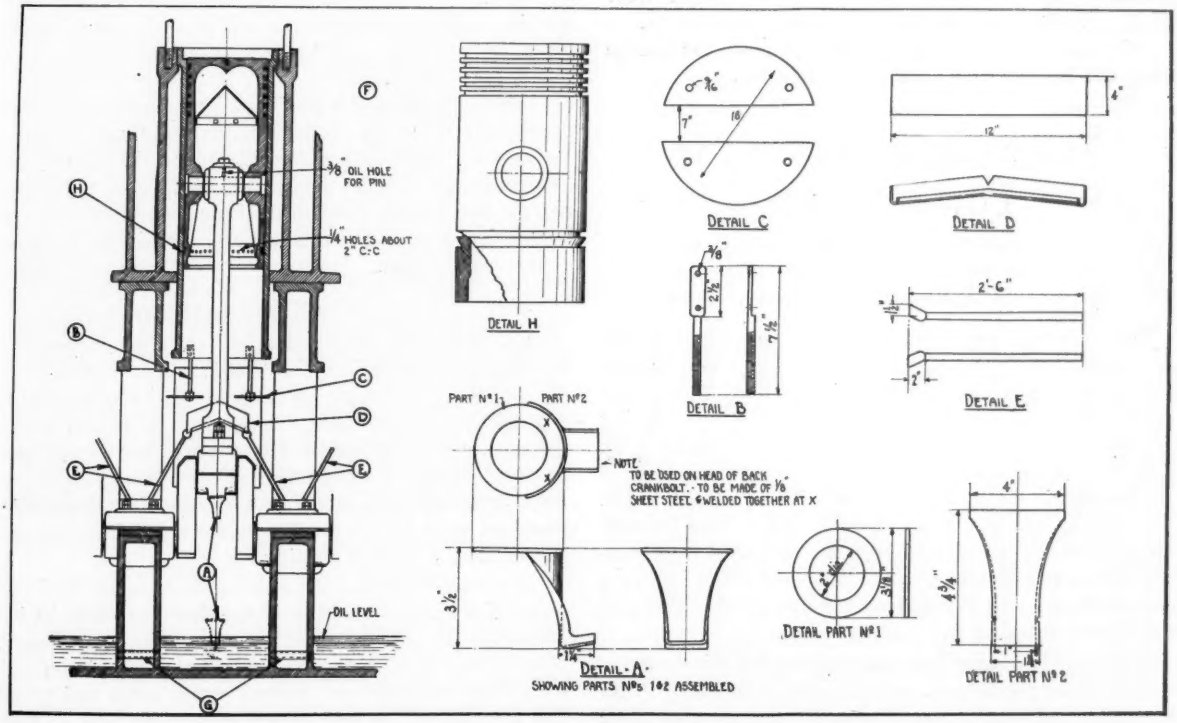
By R. S. Martin

IN THE early days of Diesel engine building the lubricating system usually consisted of a splash system using oil and water. While this system was fairly satisfactory, there were several drawbacks to its use. In cases of the old types of engines to substitute straight oil lubrication in place of the oil and water lubrication and also to substitute some direct method of lubrication in place of the splash system for which the engines were designed.

An example of how an old type lubricating system may be changed to advantage is shown by the accompanying details of the changes made on a 225-hp. Type A Busch-Sulzer Bros. Diesel engine. This engine was first introduced into this country in about 1898 by the American Diesel Engine Co., which is now a part of the Busch-Sulzer Bros. Co.

Although these engines have not been built for 10 yr., there are still quite a number of them in daily operation. In the Southern section of the country, available records indicate there are 100 of these engines with a total of 20,730 b.hp. For that reason the method described may be of interest to operators of these engines or to operators of engines using an old oil and water system of the splash type.

Referring to the accompanying illustration, with the details of the parts, it should be noted that it is necessary that a baffle be placed above the piston pin as shown at F.



STRAIGHT OIL LUBRICATION SUBSTITUTED FOR THE ORIGINAL OIL AND WATER SPLASH SYSTEM

where a fuel oil, high in sulphur, was used and the engine was not kept in first class condition, the products of combustion, on coming in contact with the water in the oil, would form acids which corroded the engine parts. As a result, the oil had to be renewed, at a considerable cost for lubrication, or else the repair cost would mount to rather high figures.

Modern engines are equipped with positive pressure lubricating systems which permit the use of a greater variety of lubricating oils, avoid the corrosion of engine parts, are positive and are clean.

Many and various methods have been devised by owners This keeps the oil from splashing against the hot head of the piston, where it would carbonize and then drop back into the crank case and seriously affect the lubricating qualities of the oil.

This baffle is made of galvanized iron of about No. 18 or 20 gage, is placed 2 or 3 in. from the top of the piston and is held in place by cap screws. It is also necessary to cut a groove under the wiper ring on the lower end of the piston as shown in a separate detail H. This groove should be cut into the ring groove, under-cutting the ring at least $\frac{1}{16}$ in. and then cut down to make a $\frac{1}{2}$ in. gap so that the oil will not reach across the groove and pass

the rings. Drill ¼ in. holes 2 in. apart in the bottom of the groove so that all of the wiped oil will pass back into the crank case.

Holes should be drilled in the walls dividing the crank pits and pieces of 1½ or 2-in. pipe placed as shown, so that the oil level will be the same in the crank pits. The oil level is maintained in the crank pit high enough to give the dipper on the bottom of the connecting rod 1 in. immersion in the oil. This is sufficient to lubricate the piston pins properly and also to splash enough oil into the trough, fastened to the doors of the crank case, to give the main bearings a copious supply of oil.

If it is desired to make the withdrawal of oil more convenient, it is a very simple matter to place a drain pipe in one of the crank pits. An oil gage which will indicate the level of the oil in the crank case is also an aid in operation.

This oiling system has been tried out on a number of installations and it has been found that 25 per cent less oil is required than with the old system. Furthermore it was formerly necessary to take up on the crank and piston pin bearings every two weeks while with the new system it is only necessary to take them up every 3 months. Wear on all parts has been reduced by at least one fourth.

It should not cost more than $50 to make the change along the lines of the accompanying sketch.

Floor Construction for Power Plants

It Is Essential in Power Plant Work that Floors Have a Wearing Surface Which Is Uniform, Even and Hard

FLOORS FOR power plants must be constructed of materials which are non-combustible and which present a hard surface so that it will withstand hard usage. For these reasons wood floors are not used except during periods of construction. A good grade of paving brick may be used for the floor of a boiler room where there is no basement. To make this type of floor of real value, it should be laid on a sub-base of concrete. This immediately raises the question of economy resulting from raising the concrete sub-base to the floor level and giving it a cement finish, thus eliminating the cost of the brick and the labor for laying it.

Concrete has come into common use for the construction of power plant floors. In the boiler room, boiler room basement and engine room basement the concrete floor presents a smooth, uniform surface which is permanent. In the turbine room the surface coat of cement may be colored so that the room will have a more pleasing appearance, or colored tile may be laid on the floor slabs which need then be finished off only in a rough manner.

The wearing course of a concrete floor should preferably be mixed in the proportions of one sack (1 cu. ft.) of Portland cement to 2 cu. ft. of fine aggregate, the minimum thickness of this course to be ¾ in. The mortar should be of the driest consistency possible to work with a sawing motion of the strike-board. This wearing course should be placed immediately after mixing and it should be placed on the fresh concrete base before the latter has appreciably hardened.

Concrete May Be Colored

It is often desirable to produce a colored floor surface without resorting to special floor tile. Floors of this sort usually are not to be subjected to heavy abrasive traffic so that such weakness as may be introduced by the use of coloring material in the top, or wearing course, is not important. Obviously, the coloring matter should be confined to the top course only.

Only mineral coloring pigments should be used, as other pigments fade rapidly and reduce the strength of the cement to a marked degree. Mineral colors vary in quality and show a tendency to fade, depending upon their quality. The amount of coloring materials added should not exceed 5 per cent by weight of the cement for heavy traffic floors as larger quantities may affect the strength of the mortar or concrete to an injurious extent. For light foot traffic floors and for ornamental borders, 10 per cent may be used and will produce deep shades. Different shades of color can be secured by varying the amount of coloring material or by mixing two or more colors.

Red oxides of iron produce the most permanent red tints. Venetian red should be avoided as it tends to run and fade. Manganese oxide is probably the best material for black, although a high grade of lamp black or carbon black is generally satisfactory. Common lamp black should not be used.

Intensities of shades produced by mineral colors will be slightly increased if the materials are mixed for a longer time than required for ordinary work. It has also been suggested that an application of a solution of magnesium fluosilicate or sodium silicate may be effective in setting the color in the concrete and checking a tendency of the color to fade.

Protection of Newly Laid Floors

Efficiency of a concrete floor surface depends upon the workmanship in laying the wearing course and upon proper protection during its early hardening by a covering which will keep the floor damp for at least two weeks. Experience has demonstrated that a wearing course composed of Portland cement and a suitable aggregate correctly proportioned, mixed and deposited and properly protected after finishing will produce a satisfactory wearing surface, free from dusting.

If a wearing surface crumbles or dusts under moderate traffic, the wearing qualities of the floor can often be improved by the application of some hardener or treatment. Magnesium fluosilicate, sodium silicate, aluminum sulphate, zinc sulphate and various gums, soaps and paraffins are among the best known substances used to treat concrete floors. The market affords a number of compounds which are widely recommended for inclusion in the body of the concrete. Instructions for the use of these compounds invariably call for many of the methods and practices which are known to be essential for successful concrete floors built without the inclusion of integral compounds.

Decorative floor paints or coatings may be had in considerable variety from responsible manufacturers. Almost without exception these paints require that the floor be thoroughly clean and dry when the paint is applied. A fairly wide range of colors is available and, while these paints wear off under foot traffic, they are, in general, as permanent and wear resistive as those used on wood floors.

Layout and Operation of 1200-lb. Steam Plant*

STEAM IS INITIALLY RAISED TO 1200 LB. AND 700 DEG. F. AND USED IN A 3150-KW. TURBINE WHICH OPERATES WITH A 350-LB. BACK PRESSURE

AT THE WEYMOUTH power station of the Edison Electric Illuminating Co. of Boston there has been installed a high pressure power plant which consists of a boiler and turbine designed to operate at a maximum steam pressure of 1200 lb. per sq. in. The boiler generates the steam and superheats it to 700 deg. F. total temperature and then delivers it to the turbine. From the turbine the exhaust at 360 lb. pressure returns to the boiler where its temperature is again raised to 700 deg. F. The steam

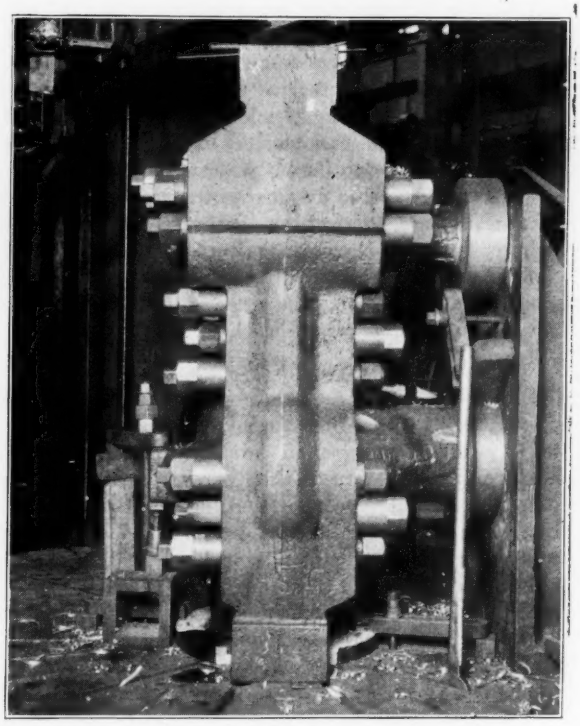


FIG. 1. SIDE VIEW OF TURBINE CASING SHOWING FLANGE BOLTING AND STEAM CONNECTIONS

is then delivered to the main steam header for use in the normal pressure (350 lb.) turbo-generators. The high pressure boiler and high pressure turbine are operated together as a unit, giving complete certainty as to steam path and division of load.

This 1200-lb. steam boiler is a modification of the conventional cross-drum type, the heating surface consisting of 2 in. tubes 15 ft. long, arranged in three passes. The tubes are separated into upper and lower banks, with a primary superheater between. Above the upper bank of tubes, is a secondary superheater or reheater. The tubes of this reheater are at right angles to the tubes in the main heating surface and are so arranged that the gas passes throughout them between the first and second passes of the boiler. The main boiler baffle between these passes is extended up into the reheater, by means of an adjustable damper. When this damper is in its lowest position, all the gas is forced to pass through the reheater. When the damper is raised to its highest position, the reheater is bypassed and is practically out of service. Intermediate positions of the damper give varying degrees of effectiveness to the reheater. The boiler is fired by the conventional type of Taylor stoker.

Special arrangement of safety valves is used to protect the boiler. The cross-drum is provided with a series of safety valves, set to blow at 1200 lb. pressure. In order to protect the primary superheater, a safety valve is placed on its outlet and set to blow at 1190 lb. It is possible that after operating, the seats of these valves would be destroyed, which would render it necessary to shut the boiler down and reseat the valves before continuing operation. In order to avoid undesirable wear of the seats of the main valves, a warning to the fireman is provided consisting of two telltale valves. These are placed on the discharge from the primary superheater and are of small diameter, set to blow at 1170 lb. per sq. in. Between them and the steam connection, are placed gate valves.

In operation, one of these gate valves will be closed; the other open. Should the pressure rise near the 1200-lb. point, the first telltale valve will blow, giving the fireman an opportunity to reduce the pressure on the boiler in time to prevent the main valves from blowing. The telltale valve which has blown can then be shut off by the gate valve below it and the other telltale valve put into service by opening its gate valve. The first telltale valve can then be removed and reseated if necessary. In this way, the boiler can be kept in continuous operation even though the safety valves should require special care.

Control for the high pressure boiler is of the Bailey electric relay type. In operation, the 1200-lb. boiler will not be regulated by the master pressure controller of the normal pressure boilers but will be operated by the push buttons on its own control board. The 1200-lb. turbo-generator is of the straight impulse type, provided with 20 stages, each stage having a single row of buckets. The exhaust pressure is constant at 360 lb. per sq. in., variable temperature.

LOCATION OF LEAK-OFF POINTS

There are three leak-off points from the high pressure gland and two from the exhaust gland. The first leak-off point from the high pressure gland delivers steam direct to the exhaust of the turbine. The intermediate high pressure and the first exhaust leak-off deliver steam at a maximum pressure of 26 lb. ab., to the closed feed water heater, connected to the 12th stage of the main turbo-generator with which the high pressure turbine is operating. The last leak-off on each gland is connected to a surface condenser at atmospheric pressure.

Piping for the installation consists of a single high pressure line, connecting the primary superheater outlet nozzle on the boiler to the turbine throttle, an exhaust line connecting the turbine exhaust to the reheater inlet on the boiler and a third line, connecting the reheater discharge on the boiler to the main steam header. Between the high pressure steam line and the exhaust line, is a

*Description by Stone & Webster, Inc.

bypass supplied with a desuperheater. No stop check valve is supplied, as no other boilers are connected into the line.

After flowing through the turbine, the steam is returned to the reheater in the boiler and, after passing through the reheater, it flows to the main steam header. A stop check valve is provided on the outlet of the reheater, in order to prevent steam from the main header flowing back into the reheater. A simple check valve is supplied in the exhaust line between the turbine and the reheater, in order to prevent steam, discharged from the by-pass, from flowing back through the exhaust connection into the turbine.

Oil Operated Trip Gears Are Used

In the bypass, a special type of trip valve is installed. This valve is similar in design to the turbine throttle, and is equipped with an oil-operated trip gear, but this trip is

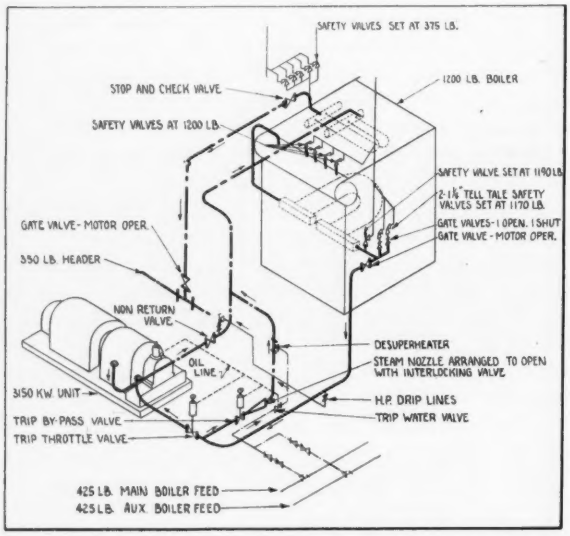

SAFETY VALVES SET AT 375 LB.
STOP AND CHECK VALVE
1200 LB. BOILER
SAFETY VALVES AT 1200 LB.
SAFETY VALVE SET AT 1190 LB.
2-1¼" TELL TALE SAFETY VALVES SET AT 1170 LB.
GATE VALVE-MOTOR OPER.
GATE VALVES-1 OPEN, 1 SHUT
GATE VALVE-MOTOR OPER.
350 LB. HEADER
NON RETURN VALVE
DESUPERHEATER
STEAM NOZZLE ARRANGED TO OPEN WITH INTERLOCKING VALVE
OIL LINE
3150 KW UNIT
H.P. DRIP LINES
TRIP BY-PASS VALVE
TRIP WATER VALVE
TRIP THROTTLE VALVE
425 LB. MAIN BOILER FEED
425 LB. AUX. BOILER FEED

FIG. 2. DIAGRAM OF THE TWO PRESSURE PIPING SYSTEM

designed so that the valve will open instead of closing when actuated. This trip gear is placed in parallel with that on the turbine throttle, the purpose being to bypass the steam immediately, should the turbine throttle be closed by the overspeed device.

Beyond the bypass valve, is inserted a nozzle for throttling the 1200 lb. steam and expanding it to 360 lb. pressure before it enters the exhaust line and is returned to the boiler reheater. Beyond this nozzle are placed a series of water jets for desuperheating the steam.

Method of Starting Up

In starting up the plant, the boiler stop valve may be opened before raising steam on the boiler, as no other boilers are on the line. The stop valve at the main steam header, and the stop check valve on the discharge side of the reheater, may also be opened. The high pressure steam line may be kept clear of water by using the blowoff from the high pressure drip pocket to the turbine exhaust line. The reheater damper should be raised so as to bypass the reheater. Steam should then be raised in the usual way. The bypass valve near the turbine should be opened as steam is raised, so as to provide a circulation of steam as soon as the pressure in the boiler exceeds that in the main steam header. In circulating steam, the superheat of the steam returned to the reheater can be regulated by means of the water supplied to the bypass desuperheater.

Since the high pressure turbine is operated in conjunction with one of the main 350 lb. pressure turbo-generators, before starting the high pressure unit, the valves between the gland leak-off points of this unit and the gland steam condenser and the 12th stage extraction heater of the corresponding main unit should be opened. Should an emergency arise a water jet condenser is provided for condensing the steam from the glands so as to care for the steam in case the condenser and heater should be temporarily out of service.

After the turbine has been warmed up, it may be brought up to speed and placed under the control of the governor, the throttle valve being opened wide. At this time the boiler is operating at reduced pressure, say between 600 and 800 lb. per sq. in. and at low capacity. Steam is flowing to the turbine under the control of the turbine governor and the excess is being bypassed through the bypass valve to the turbine exhaust and passing through the reheater to the main steam header.

The turbo-generator may be synchronized and placed on line in the usual way except that as soon as the generator circuit breaker is closed, the turbine governor should be placed out of operation by tightening the synchronizing spring sufficiently to bring the range of the governor above the synchronous speed of the machine.

Normal Operation

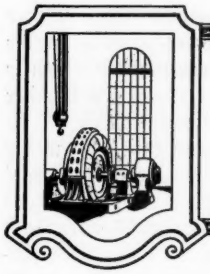
During normal operation, the turbine develops power in accordance with the steam passing through it. It operates at synchronous speed in parallel with the main bus and its output is governed entirely by the steam pressure.

In general, the process of shutting down the plant is exactly the reverse of starting up. The boiler pressure should be reduced, attention being given to the reheater damper and the boiler feed pump, to maintain correct reheating temperatures and proper feed pressures. When the boiler pressure has been reduced to the desired point, the bypass valve may be gradually opened, relieving the turbine from load.

The turbine may now be relieved of load from the main switchboard by means of the synchronizing device on its governor and the generator taken off the line. The turbine throttle should, of course, be closed and the boiler taken off the line in the usual way. The piping system can be shut down by closing the stop valve in the 1200-lb. line at the boiler and closing the stop and check valve and the stop valve in the normal pressure line to the main header.

One special condition arises when an emergency requires the immediate shutting down of the turbine. When the overspeed or oil pressure trip of the turbine operates and closes the throttle valve, the bypass valve is opened at the same instant. This valve allows the steam to flow through an expanding nozzle having the same capacity for flow as the turbine itself and discharging the steam into the turbine exhaust through a desuperheating spray.

When the bypass valve trips open, it opens also a water valve which supplies water from the 425-lb. boiler feed system to the desuperheater spray nozzles. The effect of this bypass is to reduce the high pressure steam to 360-lb. pressure and remove its superheat. It is then passed through the reheater in the boiler in the usual way and delivered to the main header.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Motor Drives for Turbine Auxiliaries

MODERN PRACTICE IN THE APPLICATION AND CONTROL OF MOTORS FOR AUXILIARY DRIVES. BY H. W. SMITH*

AS MENTIONED in the article "Motor Applications in the Boiler Room" which appeared in the July 1, 1924 issue of Power Plant Engineering, electric motors are rapidly coming into favor for the driving of auxiliaries in power stations, not only because of the inherent advantage of the electric motor itself but also because of the change brought about in methods of maintaining heat balance. In this article we will discuss the electric motor from the standpoint of its use in the turbine room and on the condenser floor.

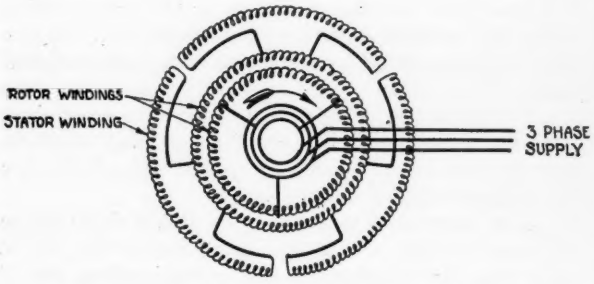


FIG. 1. ARRANGEMENT OF WINDINGS IN SHRAGE TYPE VARIABLE SPEED A. C. BRUSH SHIFTING MOTOR

Among the most important turbine room auxiliaries are those associated directly with the condenser. These are essential to continuous operation and an interruption cannot be tolerated.

Loss of vacuum due to interruption of circulating water reduces output of turbine 60 per cent and the rise of temperature on the turbine blades at the low pressure end, consequent on the heat from the windage losses may cause damage.

For this reason recommended practice is to use two circulating pumps, two condensate pumps and two air removal pumps. Sometimes, however, steam air ejectors are used in place of a duplicate air removal pump. These pumps should be preferably supplied from different sources of supply.

Some companies have adopted the practice of making one of the two circulating pumps duplex driven (steam and motor).

By use of this type of drive two results are obtained:

(a) A flexible unit is available which by varying the load on the turbine drive, will supply the required heat variations for maintaining a constant feedwater temperature.

(b) In case of trouble in either steam supply or the electric service, the opposite drive will automatically pick up the load and thus keep the condenser water in circulation. The other circulating pump which is provided with a motor only is used as a reserve or in cases where it is desirable to operate two circulating pumps at a time when high circulating water temperatures occur.

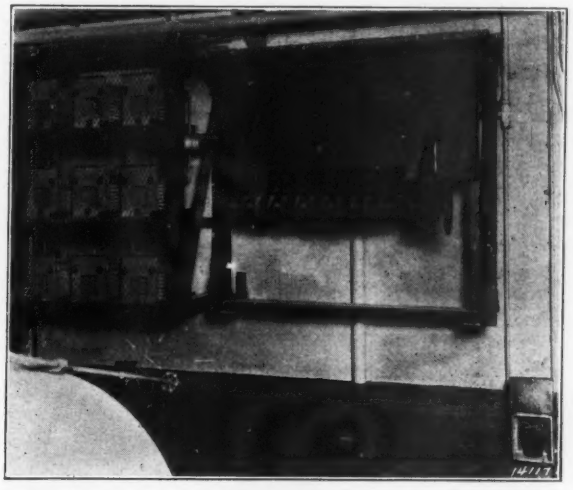


FIG. 2. RESISTORS AND CONTROL SWITCH USED FOR CIRCULATING PUMP MOTOR CONTROL AT COLFAX STATION

In most circulating systems, the intake and discharge are at the same level, so that siphonic action takes place. Thus the only head that the pump has to work against is the frictional head in the condenser and piping. The relation between the friction head and discharge is approximately a square relation, so that assuming no change in pump efficiency the power will vary as the cube of the gallons per minute. If a speed of a pump is varied the discharge varies with the speed and the head as the square of the speed, and the power required as the cube of the speed.

With wound rotor induction motors, the speed variation is simply made, and though the efficiency is reduced at lower speeds, on account of the loss in the secondary resistors, the fact that the power varies as the cube of the speed, means that the kw. losses are low. Another possibility is the use of a two speed motor. The speeds required

*General Engineering Dept., Westinghouse Electric and Mfg. Co.

are generally other than 2 to 1, so that a squirrel cage motor with two separate stator windings is used. For instance, a 24 pole and a 36 pole winding.

Circulating pumps vary in size from 50 to 500 hp. and speeds vary from 700 to 290. When speed reduction is used, a range from full speed to 80 per cent speed in 4 to 6 steps is usual. Where two winding motors are used, the speeds are generally 100 per cent for one winding and 66 per cent for the other winding.

In many cases a definite acceleration is desired. This can be obtained by substituting for the current limit acceleration a small motor operated master switch which operates the contactors at definite time intervals. These switches are arranged with various reduction ratios in worm and spur gearing so that various times can be ob-

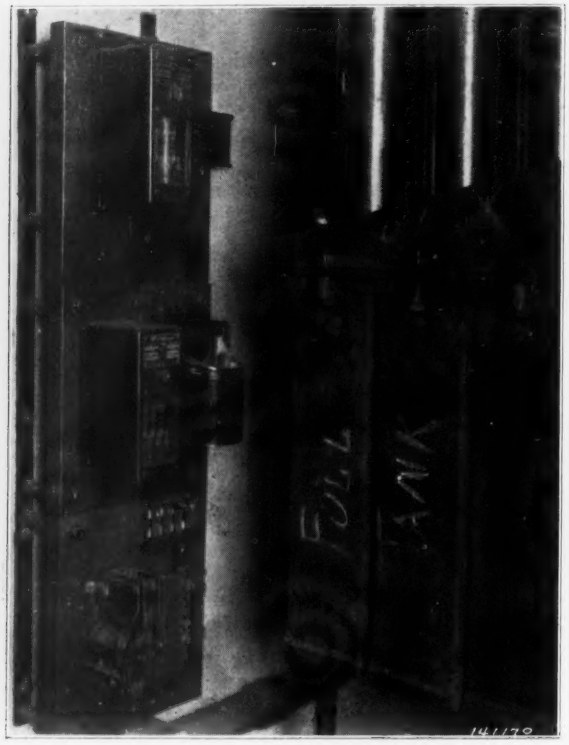


FIG. 3. CONTROL EQUIPMENT FOR CIRCULATING PUMP MOTORS AT COLFAX

tained from 1 min. downward by selecting the right combination.

Slow speed induction motors have a very poor power factor. For this reason some companies are adopting synchronous motors. These motors can be made with leading power factor to give corrective kv.a. and improve the power factor of the auxiliary system.

As an example of typical control equipment, we will describe the equipment for 450 hp., 3 phase, 2300 v., 60 cycle, 290 r.p.m. type "CW" motor for driving circulating pumps in Colfax Station of Duquesne Light Co. Figures 2 and 3 illustrate this installation.

The circulating pump motor is provided with two electrically operated oil circuit breakers in order that the motor may be operated either from the house transformer or from the house generator bus.

Relay equipment is provided for automatically transferring the motor from one bus to the other upon failure of voltage or low voltage. This is accomplished by means of an undervoltage relay which trips the breaker which is connected to the low voltage bus and closes the breaker which connects the motor to the other bus.

The motors are of the wound rotor type. A motor operated cam controller is used to cut out the external resistance in the rotor circuit in bringing the motor up to normal speed. This control is so interlocked with both primary breakers that the controller must be in the starting position before the primary breakers can be closed. Each motor is equipped with an electrically operated non-reversing mechanism of the ratchet type which prevents the pump from running the motor backwards in case of failure of voltage supply to the motor. This ratchet mechanism engages teeth on the shaft coupling when voltage is not impressed upon the motor terminals and disengages the ratchet device when voltage is impressed upon the motor terminals.

The relay equipment is so arranged that if both buses should be dead or have under voltage at the same time the motor will not be connected to either bus. If voltage is low on one bus and the motor is transferred to the other bus which might also have low voltage the relay equipment will cause both breakers to remain in the open position unless voltage should return on the original bus. In this case the motor would be again connected to the original bus.

A distinction is made between under voltage and short circuit. In the case of short circuit or overload, induction type overload relays operate to open the circuit breaker and the motor is shut down.

As an example of contactor type—Fig. 4 shows a type "C" a.c. controller, for a 500 hp., 3 phase, 2300 v., 60 cycle type "CW" motor for Public Service Company of New Jersey. The two interesting features are the use of direct current for the holding magnets on the contactor and the use of definite time limit acceleration.

Another type is shown in Fig. 5. This is a motor operated drum contactor controller for use with a 3 phase, 60 cycle, 2200 v., 800 hp. type "CW" motor for Commonwealth Edison Company. The primary is controlled by an oil circuit breaker while the secondary is controlled by the equipment shown in the above photograph. Speed control switches are included so that speeds of 65, 80 and 88 per cent of full load speed can be obtained. A time relay is supplied to give a time of from 10 to 30 sec. on the first step.

Air pumps of the LeBlanc type usually run at 700 r.p.m. and the horsepower ranges up to 125. Constant speed motors are usually used. Condensate pumps usually run at 1750 r.p.m. and the horsepower ranges up to 125. Here, too, constant speed motors are usually used.

A. C. Versus D. C.

All large generating stations generate and sell 3-phase alternating current and, therefore, it is logical to use a.c. power and a.c. motors for auxiliaries. For constant speed service a.c. motors are simple, reliable and cheaper than d.c., both in first cost and maintenance.

The various points can be summed up as follows:

A. C. Advantages

(1) Best for constant speed on account of greater reliability of squirrel cage motors.

(2) Lower first cost and maintenance.
(3) High voltage (2300) can be used for large motors.
(4) Power can be supplied from main generating bus in emergency.
(5) Simpler and cheaper starters (can start on full voltage).

Disadvantages

(1) Where large speed variation is required, motor and control are inefficient unless complicated polyphase commutator types used.

D. C. Advantages

(1) Suitability to variable speed applications.
(2) Storage battery can be used as emergency supply.

Disadvantages

(1) More expensive motors and starters.
(2) Greater investment in auxiliary converting equipment.
(3) Larger maintenance.
(4) Difficult to build in large sizes for high speeds.
(5) Low voltage in general use necessitates expensive cable runs and buses.

Speed Control of A. C. Motors

The induction motor is inherently a constant speed motor and methods of obtaining variable speed from induction motors can be summarized as follows:

1. Variable frequency.
2. Pole changing.
3. Secondary resistance with wound rotor motors.

Method 1 cannot be used unless a separate generator is available to supply the motors. It has been used in marine practice and for power house work estimates have been made on a special house generator turbine driven for supplying power to forced and induced draft fans, speed control to be obtained by varying the speed of the turbine. Methods 2 and 3 are generally used and are the only methods so far adopted for power house auxiliaries.

A vast amount of work has been done by European engineers in attempting to develop polyphase a.c. commutator motors. In this country two types have been mainly considered. One is the brush shifting series type motor already mentioned under forced and induced draft fans. While an efficient motor, it is expensive in first cost and maintenance, and does not seem rugged and simple enough for power house auxiliary service.

Some interest has recently been taken in the development of the Schrage Type of a.c. commutating motor for variable speed service.

This motor is similar in construction to the wound rotor induction motor, except that in addition to the slip rings it has a commutator. The arrangement of the primary and secondary windings is inverse to that of most wound rotor induction motors. The primary winding is located on the rotor and is connected to the source of supply by means of slip rings. The secondary winding is located on the stator. In addition there is a regulating winding on the rotor placed in the same slots as the primary winding. This regulating winding is connected to a commutator. Two sets of brushes on this commutator connect in series with the secondary winding on the stator.

When the brushes are in the same relative position on the commutator the operation is exactly the same as an induction motor. The speed regulation, however, will be slightly greater than that of the standard wound rotor induction motor, due to the brush contact resistance. The regulating winding is fed by transformer action from the primary winding in the same slots. With a given separation of the brushes, therefore, the voltage between brushes will be constant. The frequency, however, will vary with the rotor speed, and will be equal to the slip frequency since the brushes are stationary. Thus a voltage is added in series with the secondary winding, and the speed will change until the voltage induced in the secondary winding is exactly equal and opposite to the voltage taken from the commutator. The speed will be different from the synchronous speed of the motor. It can be readily seen that if the voltage taken from the commutator is in such a direction as to add to the secondary voltage, the motor will operate above synchronous speed. If this voltage subtracts from the secondary voltage, however, the operation will be below the synchronous speed of the motor. Figure 1 shows the arrangement of the windings in the motor.

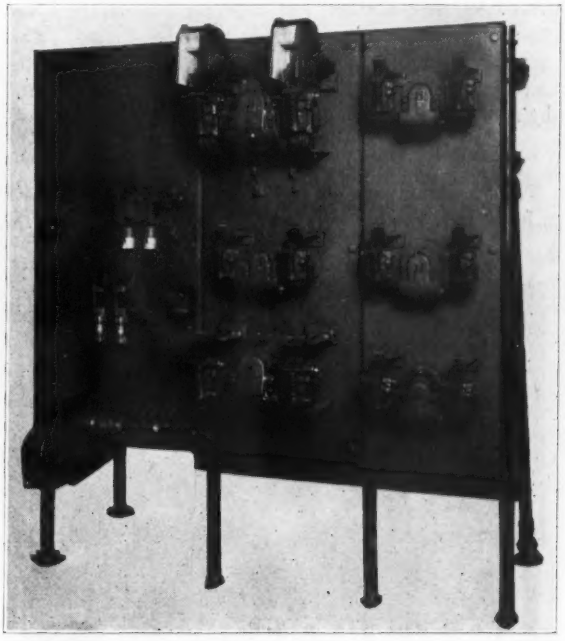


FIG. 4. CONTACTOR TYPE CONTROLLER FOR 500-HP. 3-PHASE MOTOR

In operation this motor is similar to a d.c. shunt motor with field control, except that the full load torque is the same at high speed as for low speed. The speed is nearly constant for any brush setting, varying only 5 to 10 per cent from the no load to full load torque. The efficiency is high for all operating speeds, since no power is wasted in external resistance. The power factor is rather low at light loads and at low speeds. In this respect, it is similar to an induction motor, however, when the motor is operating at high speed under load the power factor is unity and may even be slightly leading. The usual speed ratio obtained with these motors is 3 to 1. This ratio, however, may be changed slightly in the design of the motor in

order to meet the special operating conditions. Since the regulating windings act like a transformer and is connected directly to the commutator, the voltage short circuited by the brushes will be the same, regardless of the conditions of speed and load on the motor. The currents carried by the brushes, however, will vary with the torque on the motor. The starting current of these motors is only about one and one-half times the full load current. The starting torque with the brushes set for the lowest speed is about one and one-half times the full load torque.

Control

These motors may be started on full voltage when the brushes are set for the lowest speed. For the primary control then, it is only necessary to have a circuit breaker, knife switch or contactor. In order to control the speed of the motor both sets of brushes must be shifted. This is accomplished by a rack and pinion which moves the brush gear. This mechanism is operated either by hand or by means of a pilot motor.

Physical Limitations

The maximum possible size of this type of motor which can be built is limited by a number of factors. First, the

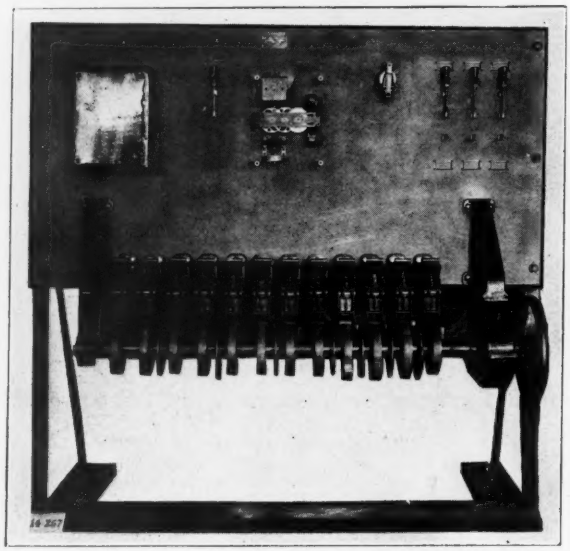


FIG. 5. MOTOR OPERATED DRUM CONTROLLER FOR 800-HP. 3-PHASE, 2200-V. MOTOR

peripheral speed must be kept within safe limits, also, since the brushes at all times short circuits the maximum volts per bar, the voltage on the commutator must be low. This requires that the brushes carry a relatively high current. The size is therefore also limited by commutation. It is probable that the largest Schrage motor which can be built is about 350 hp. for the 60 cycle machines with as high as 15 or 20 hp. per pole, and in sizes up to 600 hp. for the 25 cycles machines with as high as 40 hp. per pole. The motor is probably limited to 500 v. since the primary winding is located on the rotor.

It is probable that considering first cost and maintenance, either the less efficient wound rotor motor, or a combination of synchronous motor generator set with variable voltage control supplying standard direct current motors will be preferable to polyphase a.c. commutator motors.

In connection with the motor and control equipment for auxiliaries, the fundamental requirements are ruggedness of equipment and continuity of service. The operation of large units of 30,000 kw. or over should not be endangered by an auxiliary motor or control equipment.

These large units often operate for two or three months at a time without shutting down and there is very little opportunity for inspecting the equipment while in service. The power requirements for the auxiliaries in a large station are so great that the whole design should be handled from the viewpoint of a large substation located in the power house. The currents which can flow under short circuit are so great that standard industrial control equipment in most cases is undesirable.

Standard auto-starters, for instance, are designed only to rupture the locked current of the motor. If closed on to a short in a large station, the short circuit currents will probably be so great that the auto starter will fail from the mechanical and thermal elements of the current. In old stations having this equipment which has grown in size so that the auto starters are a danger and where modern equipment cannot be installed for reasons of finance or otherwise, we recommend mounting the auto-starters behind steel panels to protect the operator if the auto-starter fails.

In an attempt to overcome these difficulties, starting bus schemes have been installed in several large stations. Two breakers suitably interlocked—one for starting and one for running—are used for squirrel cage motors. A starting bus obtained from taps on a transformer or from a large auto transformer, is used to give starting voltage.

Starting Induction Motors on Full Voltage

In recent years there has been a considerable demand for simplification in the control equipment of induction motors. This has led to the suggestion that motors be started on full line voltage.

When full line voltage is applied to an induction motor, the current taken is from 6 to 10 times the normal full load current for high speed motors and 4 to 6 times for motors with 14-pole and higher.

The sudden application of so large a current tends to cause shifting of the coils and if often repeated may finally chafe through or crack the insulation when it becomes brittle with heat and age. This tendency to move is present in any motor when the current is changed and of course the amount of movement depends on the value of current and turns in the coil and the stiffness of the coils.

It is probable that the following represent sizes which can be guaranteed for satisfactory operation with normal life of insulation:

4 pole and 6 pole squirrel cage motor up to 125 hp.
8 pole and 10 pole up to 150 hp.
12 pole and 14 pole up to 200 hp.
16 pole and above up to 300 hp.

For wound rotor motors, the case is different, as the normal brush capacity of the rotor circuit is approximately two times full load and special design is necessary to take care of the rotor currents which may be four to eight times full load when the motor is thrown on the line with a shorted rotor circuit.

New Type of Single-Phase Motor*

MOTOR HAS STARTING CHARACTERISTICS OF A SERIES MOTOR AND WHEN UP TO SPEED THOSE OF A SHUNT MOTOR. BY S. R. BERGMAN†

POSSESSING THE characteristics of a shunt motor over the running range and those of a series motor during the starting and accelerating period, the motor described in this article is a novel departure in a. c. motor design. The change over from the characteristics of the series motor to that of the shunt motor is accomplished in this new motor without the use of any external automatic device. Since the motor is a combination of a repulsion motor and a squirrel cage induction motor, for want of a better name, it will be referred to as the squirrel cage repulsion motor.

Through the work of Steinmetz and Alexanderson, the characteristics of the plain repulsion motor are well understood. In Fig. 1 is shown, diagrammatically, Professor Elihu Thomson's well-known repulsion motor. This motor

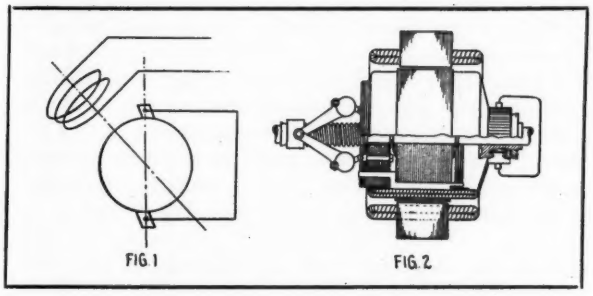


FIG. 1. DIAGRAM OF THOMSON'S REPULSION MOTOR
FIG. 2. MOTOR DESIGNED WITH AN AUTOMATICALLY ADJUSTABLE REACTANCE

has in many respects the same characteristics as that of a series type d. c. motor. It differs, however, from the operation of such motor in some respects and in examination of such differences, one in particular is rather striking; namely, the difference in the speed and torque curve. The series type d. c. motor will attain very high speeds if the load is removed; whereas, the repulsion motor will not run away, but will stop at a certain limited speed. The reason for this limitation in speed is due to the influence of the currents in the coils short-circuited by the brushes, and it may be stated that the larger these currents are, that is, the poorer the commutation, the lower will be the running free speed.

With this observation in mind, the writer conceived the idea that if it were possible by artificial means to exaggerate the influence of these short-circuited currents then it should be possible to so limit the running free speed that the result would lead to a nearly constant speed motor. In order to carry out this thought, a motor was made a number of years ago in accordance with Fig. 2. The field carries a single winding corresponding to the field winding in Fig. 1. The armature carries a commutated winding with its short-circuited brushes in accordance with Fig. 1, but in addition, there are placed in the same slot as the commutated winding, the bars of a squirrel cage. These bars are extended, as shown in Fig. 2, at one end projecting through a laminated ring rigidly attached to the shaft. Inside this laminated ring moves a circular core which is acted upon by a centrifugal mechanism in such a fashion that when the motor is at standstill, the moving core is entirely inside of the laminated ring, and when the motor speeds up, the inside core is moved out, until, near synchronism, the core is entirely moved outside the laminated ring. This mechanism, therefore, provides the squirrel cage with an automatically adjustable reactance which is a maximum at standstill and a minimum when running near synchronism.

When the motor is at standstill, the squirrel cage carries a comparatively small current due to the high value of the adjustable reactance, and the current is, therefore, flowing mainly in the commutated winding. Therefore, at standstill, this motor possesses about the same torque and starting current as in the case of the plain repulsion motor, Fig. 1. It is well understood that at synchronism the plain repulsion motor sets up a circular revolving field similar to that existing in the polyphase motor. Hence, at synchronism, the squirrel cage revolves at the same speed as this revolving field and is, therefore, at this speed, not producing any torque. Above synchronism, currents

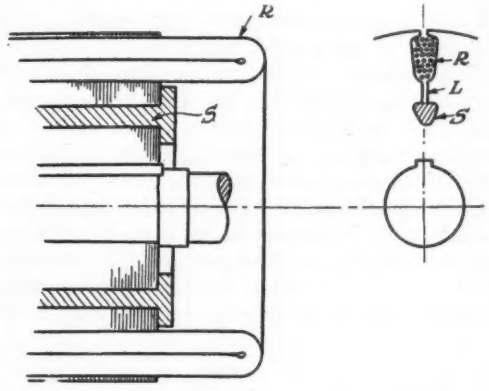


FIG. 3. MOTOR HAVING BOTH A COMMUTATED WINDING AND A SQUIRREL CAGE WINDING

are generated in the squirrel cage, the condition being very similar to that of an induction generator. The torque in the squirrel cage is then a generator torque, thus opposing the motor torque in the commutated winding. Tests show that this motor will only exceed synchronism by 1 to 2 per cent. As soon as the speed drops below synchronism, the squirrel cage becomes active, producing a motor torque, and at these speeds, both the squirrel cage and the commutated winding pull together. Tests show that the maximum output, which occurred at about 10 per cent slip, was 250 per cent of the normal output; that is, very similar to a well designed polyphase induction motor. The power-factor was excellent; i. e., close to unity, which is far better than that of either a plain repulsion motor or a squirrel cage induction motor, for reasons which will be explained in the following. The commutation of this motor was excellent, as good as that of a well designed d. c. motor

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†Consulting Engineer, General Electric Co.

with commutating poles. A brief theory of the commutation will be discussed later.

Although this motor performed in accordance with expectations, it was felt that it was capable of further development toward the end of eliminating the moving parts. The thought naturally presented itself as to whether or not it would be possible to make the adjustable reactance an integral part of the motor proper.

The next step in the development was an armature structure shown in Fig. 3. The squirrel cage S is placed underneath the commutated winding R and the slots carrying these two windings are inter-connected through the narrow slot L.

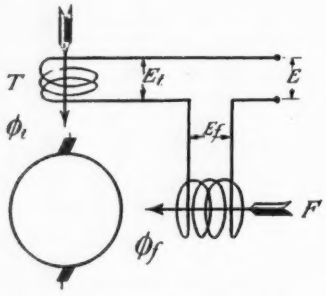


FIG. 4. REPULSION MOTOR WITH FIELD WINDING RESOLVED INTO TWO PARTS

No external cores are used, the result being that the squirrel cage is given a permanent high reactance. Since this is the type of motor which was ultimately adopted for production, no further account will be taken of the motor, as shown in Fig. 2, which has merely been mentioned as being one link in this development.

In order to explain the working of the squirrel cage repulsion motor, shown in Fig. 3, the conditions existing in the plain repulsion motor will first be briefly considered. The field winding is resolved in two parts at right angle in space shown in Fig. 4. That portion of the field winding which magnetizes in direct opposition to the armature is called the compensating or transformer winding T. That

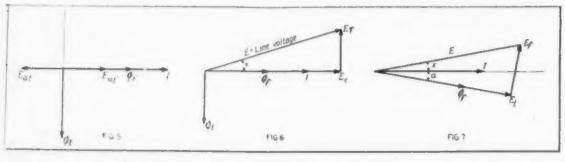


FIG. 5. VECTOR DIAGRAM, SHOWING CURRENT, VOLTAGE AND FLUX RELATIONS IN REPULSION MOTOR

FIG. 6. ELEMENTARY REPRESENTATION OF THE PLAIN REPULSION MOTOR

FIG. 7. ADDITION OF REACTIVE SQUIRREL CAGE IMPROVES POWER FACTOR

portion of the field winding which magnetizes at right angle to the armature is called the main field winding F. The transformer winding and the armature windings ϕ_t. The field winding F has no corresponding secondary winding on the armature except the coils, which are short-circuited through the brushes. Since the influence of these short-circuited currents is small, below synchronism at least, these currents will be neglected and then the field flux ϕ_f acts as pure self-induction.

When running at speed, there are two e. m. f.'s induced in the armature, one E_{at} by alternation of the transformer flux ϕ_t and a second E_{af} set up due to the rotation of the conductors through the field flux ϕ_f. Since in a reactive coil the flux and the current are in phase and since the e. m. f. of rotation must be in phase with the field flux, the vectors I, ϕ_f and E_{af} are in time phase as shown in Fig. 5. Since the armature is short-circuited (neglecting the impedance drop) the e. m. f. of alternation must be equal and opposite to the e. m. f. due to the speed as shown in Fig. 5. Since the mutual transformer flux is 90 deg. ahead in time of the secondary e. m. f., the vector of the flux ϕ_t is placed accordingly in the diagram from which it now may be seen that the fluxes ϕ_f and ϕ_t are in quadrature in time. Numerically, $E_{at} = C \times f \times \phi_t$, $E_{af} = C \times f_o \times \phi_f$ where C = constant, f = primary frequency f_o = frequency of rotation. Hence, $C \times f \times \phi_t = C \times f_o \times \phi_f$. At synchronism $f = f_o$. Hence, $\phi_t = \phi_f$, thus confirming the statement already made that at synchronism a circular revolving field exists.

A repulsion motor may, therefore, be looked upon as formed of two elements; namely, a transformer loaded on non-inductive load in series with a reactive coil. Since, in a transformer loaded on a non-inductive load, the impressed voltage and the primary current are nearly in phase, in Fig. 6, is shown as a first approximation, the line current I in phase with the voltage E_t which is impressed on the transformer winding. If E_f is the voltage impressed on the field winding, this voltage leads the current by 90 deg. Cos x is then the power-factor and thus Fig. 6 represents in an elementary way, the diagram of the plain repulsion motor.

It is obvious that by making E_f small as compared with E_t the power-factor will be good, which means running a weak field as compared with the armature reaction. In a repulsion motor of the size here considered, the power-factor at full load would range between 80 and 85 per cent. Test on the squirrel cage repulsion motor reveals, however, the fact that the power-factor at full load is close to unity. Thus, by adding a highly reactive squirrel cage, the power-factor has been considerably raised, a fact which at first appears paradoxical. The explanation is as follows:

In Fig. 6 we assumed that the current I in the field was in phase with the field flux ϕ_f. This is, however, not quite true even in the plain repulsion motor, since, due to the losses in the iron, there always exists an angle of hysteretic advance, and in addition, the coils short-circuited by the brushes act like the secondary of a transformer loaded on mixed reactance and resistance. In such a transformer, the primary current leads the mutual flux by a certain angle. In Fig. 7, the current I leads the field flux ϕ_f by a certain angle a. Completing the diagram, it is easily seen that the power-factor has improved since the whole voltage triangle has been turned in the diagram so as to decrease the angle x. In the plain repulsion motor, the angle a is comparatively small; nevertheless, there exists in such a motor, below synchronism, a certain amount of power-factor compensation.

It is now obvious that if a separate squirrel cage is used, an effect similar to that due to the currents short-circuited by the brushes is taking place, although, in a much more pronounced way. At full load, the squirrel cage actually delivers about the same amount of energy as the commutated winding. The primary corresponding

to the squirrel cage consists of two phases; namely, the transformer winding and the field winding, each contributing about one-half of the output. Thus, at full load, each of these phases delivers about one-quarter of the output, hence the angle a has become considerable at full load and the improvement of the power-factor is, therefore, appreciable.

It has thus been proven that by adding a highly reactive squirrel cage to the commutated winding in a repulsion motor, the power-factor, below synchronism, is improved, —a result which may at first appear contradictory, and the explanation as shown above may best be summarized by the following quotations from Steinmetz:

"Exciting the field by a lagging current in the field, a lagging e. m. f. of rotation is produced which is equivalent to a leading current. As it is easy to produce a lagging current by self-induction, the commutator thus affords an easy means of producing the equivalent of a leading current. Therefore, the a. c. commutator is one of the important methods of compensating for lagging currents."

Figure 8 gives the typical relation between the speed and the torque for this type of motor. From this figure it

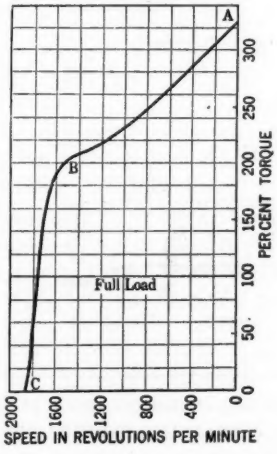


FIG. 8. TYPICAL RELATION BETWEEN SPEED AND TORQUE FOR NEW MOTOR

may be seen that the torque curve may be divided into two branches; namely, the branch A B corresponding to starting and acceleration and the branch B C corresponding to the normal running conditions of the motor. During the period A B the motor has, obviously, the characteristics of a series motor. During the period B C it possesses in a marked degree the characteristics of a constant-speed shunt motor.

As the speed decreases and the motor performs along the curve B A, the current increases, due to the fact that the field is excited by the line current. The field flux increases with the decreasing speed. At standstill, corresponding to point A, we have the following conditions:

The squirrel cage has inherently, due to its construction, a high inductance. It is then penetrated by a current having primary frequency. Its reactance, therefore, is quite high. The commutated winding, on the other hand, has inherently a low reactance and the current, therefore, will flow mainly in this winding. We may also look upon this from a somewhat different viewpoint by stating that the magnetic flux seeks the path located between the squirrel cage and the commutated winding and thus the flux, which acts as self-induction for the squirrel cage winding, is torque-producing with respect to the commutated winding.

From the shape of the curve A B C, it will be seen that the torque during deceleration increases without a break from B to A, thus securing a high "pull-up" torque, guaranteeing that the motor will pull up to speed the load that it starts. Over the branch C B, it possesses, as stated, the characteristics of a shunt motor to a marked degree, the full-load speed regulation being from 3 to 4 per cent. The branch C B, therefore, corresponds to running conditions generally obtained in a polyphase motor with low secondary resistance.

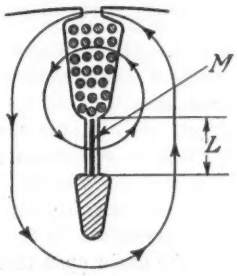


FIG. 9. DIAGRAM SHOWING RELATION OF FLUX IN NEW MOTOR

One of the great difficulties with a. c. commutator motors has always been the question of commutation. Different means have been adopted for improving the commutation, such as the use of high-resistance commutator leads in the plain series motor in accordance with Lamme, or the use of fractional-pitch winding in the repulsion motor as suggested by Alexanderson, as well as providing for the proper commutating field also suggested by Alexanderson in his series repulsion motor. In the motor we are considering, another means for obtaining good commutation has been adopted.

In the plain repulsion motor, when it is running near synchronism, the field revolves with about the same speed as the armature conductors, therefore it is reasonable to assume that at such speeds the commutation is fair. The transformer flux, which is set up by the mutual action of the transformer winding and the armature, may be considered a commutating flux since it has not only the right time phase, but also the right strength to compensate for the electromotive force induced in the short-circuited coil by the field flux. On the other hand, there is another electromotive force induced in the short-circuited coils which causes sparking,—namely, the electromotive force of self-induction. In the squirrel cage induction motor, the squirrel cage is inter-linked with the leakage flux which causes self-induction in the short-circuited coils as shown in Fig. 9. The leakage flux, therefore, serves as a mutual flux of transformation between the short-circuited coil and the squirrel cage, thus transferring the energy, which would otherwise appear as a spark, to the squirrel cage. Part of this leakage flux over the length L is, however, not inter-linked with the squirrel cage and this leakage flux would, therefore, cause a slight amount of sparking. In order to eliminate this condition, a thin sheet of metal M is introduced in this slot. This metal strip is of com-

paratively high resistance. It should now be observed that the leakage flux over the length L must penetrate this metal strip and the corresponding energy is, therefore, dissipated in heat. In other words, instead of appearing as a spark, this energy appears as heat in the metal strips. Due to the fact that the frequency of commutation is very high, it is obvious that the resistance of the metal strips can be made quite high so as not to interfere with the flux distribution in starting, which conditions have already been discussed.

Removing Oil from Exhaust Steam

By Axel G. Solomon

THERE are many ice plants where raw water ice is being made and where steam engines are used to drive the ammonia compressors.

In plants equipped with simple non-condensing engines the exhaust steam is condensed at a little above atmospheric pressure and the distilled water is used to fill cores. This usually produces ice of a very fine quality. In such plants the oil contained in the exhaust steam is blown out by leaving the drain open at the bottom of the exhaust steam separator.

Many of the larger size ammonia compressors are driven by either cross or tandem-compound engines having barometric condensers. This type of installation gives excellent economy in power used per ton of ice produced. Where fuel is cheap this drive compares favorably with motor drive.

As there is a vacuum maintained on the exhaust system, the oil proposition often proves troublesome. Some plants have hot wells that look like grease ponds.

Condensing water containing oil is not fit to use for any purpose and where the boiler feed water is taken from the hot well, the oil will cause boiler trouble.

Separating the oil from the exhaust steam is just as easy of accomplishment in the condensing as in the non-condensing plant. The drain on the separator of the exhaust line cannot be opened to the atmosphere as in the non-condensing plant, since air would be drawn in and the vacuum would be greatly lowered if not entirely lost. An oil receiver must be properly connected to the exhaust steam separator.

In the accompanying sketch an installation of this kind is shown. The oil receiver can be made of 8 or 10-in. pipe with the ends blanked off or capped. An old liquid ammonia receiver is just the proper thing if one is to be found.

It is true that there will be no pressure on this receiver but it must be remembered that a vacuum of over 20 in. will collapse a receiver if it is not made of heavy material.

At the drain opening of the exhaust steam separator place a close nipple and a gate valve (valve marked No. 1).

Extend a ½-in. line down and place angle valve No. 2 about 12 in. below valve No. 1. The swing check valve (No. 3) will guard against air being drawn in should anyone be careless in the handling of the drain valves.

A bypass line and valve (No. 4) is provided so the air can be drawn from the receiver.

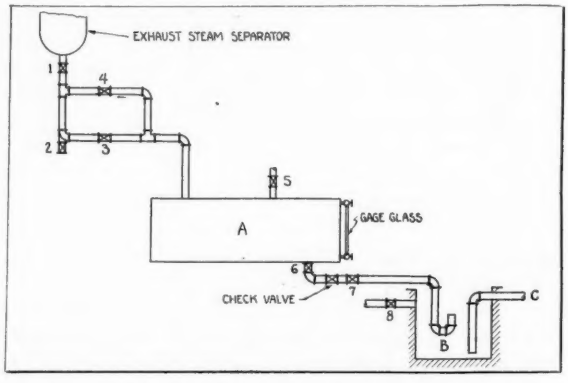
Oil and condensation will flow by gravity into the oil receiver (A). The valve No. 5 is the vacuum breaker to allow air to enter the receiver so that the oil and water will flow out at valves No. 6 and No. 7. Two gate valves with a check valve between are provided at the drain to insure against leakage of air into the receiver.

B is the tank in which the oil is separated from the water. This tank can be made from an oil barrel cut in half.

An overflow (C) is placed so the bottom end reaches to about ½ in. of the bottom of the tank. The other end is open to the sewer and is about 2 in. below the top of the tank. The valve No. 8 is for drawing the oil out of the tank and is placed about 4 in. below the overflow.

From the receiver the drain is extended into the tank so that the open end looks up, and is submerged about an inch. This allows the oil to flow more readily to the top and also seals the drain and helps to prevent air leakage.

It must be remembered that this oil receiver is really part of the vacuum system and leakage of air must be avoided. Any leakage of air into the receiver will be noticed at once, for the oil and condensation will not flow through the check valve if there is the smallest leak. The



OIL SEPARATOR ARRANGEMENT USED IN PLANT WHERE COMPOUND CONDENSING ENGINES ARE OPERATED

reason for this is in the fact that the vacuum in the receiver will be less than that in the exhaust system and the check valve will be held to its seat.

For the purpose of equalizing the vacuum on both sides of the check valve a bypass line around the check valve is provided. After emptying the receiver the check valve will stay closed until the air has been drawn out of the receiver by opening the bypass valve.

When in operation, valves No. 1 and No. 2 are left open until the gage glass shows that the receiver is full. Then close valve No. 2 and open valve No. 5. When the vacuum is broken by the admission of air, open the drain valves No. 6 and No. 7.

Water and oil will flow into the separating tank and the water will settle to the bottom and overflow to the sewer. The oil will collect and can be drawn off at valve No. 9.

After the receiver is empty the valves No. 5, No. 6 and No. 7 are closed and valve No. 2 is opened wide. Valve No. 1 is not used at all but is left open except in case that repairs are to be made.

Next the air must be drawn from the receiver by opening valve No. 4. Open this valve very little and let the condenser take the air slowly. The vacuum gage will

show a slight decrease in vacuum while the air is being drawn from the receiver.

When the gage shows the usual vacuum valve No. 4 is closed.

Oil and condensate will collect above the check valve and this weight or head will cause the check valve to open and the receiver will fill.

The line between the exhaust steam separator and the receiver will be hot if the installation is perfectly air-tight. If this line cools it indicates that air is entering the receiver and is holding the check valve shut. The bypass valve No. 4 can be opened and used if all leakage cannot be stopped.

It is best to make all pipe joints up with litharge and glycerine and the chances of leakage will be slight. While there is a vacuum on the receiver and connecting pipe work, give the whole installation a coat of heavy paint. The paint will be drawn in and will stop small leaks.

Oil that is recovered can be filtered and used for oiling shafting or any places where heavy oil is needed. Or it can be mixed with the engine oil at the filter.

If the compound engine is not provided with a steam separator and trap above the throttle valve, the loss caused by this neglect will be noticed quickly after the oil and condensation receiver has been installed. The moisture carried from the boiler with the steam will cause the receiver to fill quickly.

This moisture represents a loss which can be greatly reduced by placing a steam separator in the steam line just above the engine throttle and returning the moisture to the feed water heater by means of a steam trap.

In large plants it is best to place the oil and condensation receiver at a point below the horizontal exhaust lines. This may necessitate the placing of the receiver in a hole or well. Drain lines can then be connected into the lowest points of the exhaust lines and much oil and moisture caught that would otherwise overload the exhaust steam separator.

This low style of installation may require pressure to empty the receiver and discharge the oil and moisture to the sewer. Either air or steam can be used for this pressure.

Refrigerating by Indirect Methods

By Gilbert R. Wray

SEVERAL METHODS are used in practice whereby indirect refrigeration may be accomplished. The basic idea of this method is to cool air in a bunker room which is fitted up with direct expansion coils. Air is cooled in this bunker room and then forced into another room where it acts as the cooling agent by direct contact with the products which it is desired to keep in cold storage.

Size of the bunker room must be such that it can contain the necessary pipe either for brine or ammonia coils which should be so spaced that air can pass through them. In many cases these coils are of the direct expansion type. Air is forced through this bunker room by means of a fan. It is preferable that the air should come in at the top of the room and leave near the bottom at the opposite side from the inlet duct. From the bunker room the air is forced directly into the cooling room. Suitable baffles and dampers should be provided so that the air will be most effectively cooled and so that the direction and amount of flow may be controlled within the cooling room.

It is advisable to force the air down towards the floor of the cooling room so that it will take up heat from the products as well as from the room. The air having taken up heat will rise and pass out through the outgoing air duct, which is best located at the opposite end of the room from the incoming air duct. This arrangement tends to promote thorough circulation. The air leaving the cooling room passes back through a duct to the bunker room where it is re-cooled and again discharged into the cooling room.

It is important that the products to be cooled be so placed that the cool air will be most effective. This means that the products be so spaced that the air can pass through and around the separate pieces or containers. Boxes should not be piled with flat surfaces together but should have small blocks of wood placed between each box and the one directly above it.

Another method of indirect refrigeration is to construct the floor of the bunker room of tongue and groove boards over which a heavy coat of tar may be applied, the tar being allowed to set before using. The floor of the bunker room should slope to the center or to one side, so that the brine will run to the low point where a rotary pump should be installed.

At the low point in the floor there should be constructed a trough so that the pump suction pipe will be covered at all times with brine. The pump is used to force the brine into troughs which are located above each set of coils. The brine overflows these troughs and passes over the ammonia coils. This keeps the frost melted from the coils and gives a good cooling effect to the brine which in turn cools the air as it is forced through the brine and around the coils.

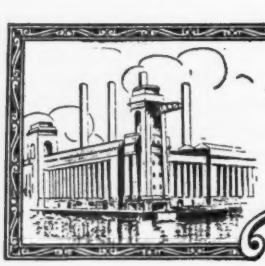
At the outlet from the bunker room there should be placed canvas or some other suitable material which will prevent the brine spray from being drawn over into the fan and then discharged into the cooling room.

Another way of discharging cold air into the cooling room is to have floor ventilators installed, the air being forced up through them and around the products which should be placed on wire trays made of non-rusting metal. The hot air rises to the ceiling and passes out through ventilators which are located at suitable points in the ceiling of the cooling room.

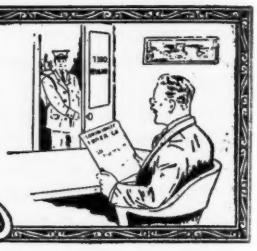
Without brine spraying over the coils, frost and ice will accumulate in a solid mass and have to be thawed off either by shutting off the ammonia and circulating air over the pipes, or by running hot water over them. These methods are unsatisfactory. The specific gravity of the brine should be kept high enough at all times so that it will not freeze to the coils.

Correction Note

On page 728 of the July 1 issue of Power Plant Engineering it is stated that the 30,000 sq. ft. condenser for the United Light & Railway Co., at Davenport, Iowa, was manufactured by the Wheeler Condenser & Engineering Co. This statement is an error, for that condenser will be furnished by the C. H. Wheeler Mfg. Co.

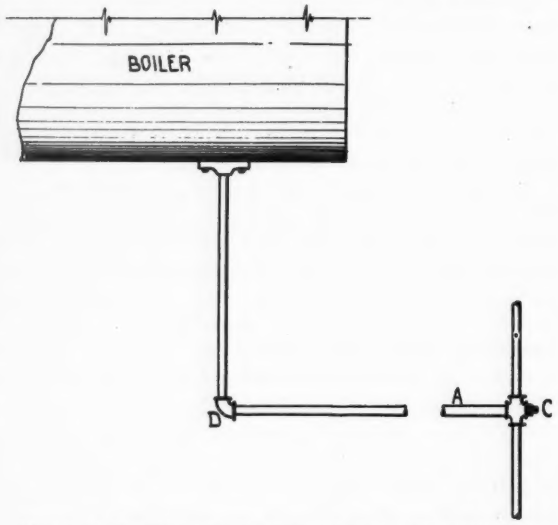


LETTERS DIRECT FROM THE PLANT



Blocked Blowoff Line

NOT LONG AGO we discovered, during the course of our routine operation, a decided falling off of the quantity of water discharging through the blowoff line on one of the boilers. Inspection showed that the line was pretty well blocked up with scale. The boilers were return tubular type, equipped with the circulation pipe connections and two valves on pipe A of the accompanying sketch. Many men fail to realize that a circulating water pipe often acts



CROSS IN BLOWOFF LINE PERMITS OF EASY CLEANING

as a surface skimmer and under certain conditions such circulating water will cause the blowoff pipe to scale up quite rapidly.

Skimmer pipes should not be used as circulating pipes; the end inside the boiler should be at least 6 in. below the surface of the water at all times while the boiler is in operation. If this is done there will be less probability of the circulation and blowoff pipes becoming closed up between cleaning out periods.

It is possible for a burned blowoff pipe to occur only when it is blocked up, no matter how high the temperature of the furnace fire, with either forced or natural draft. The blowoff pipe is safe as long as it is clear of sediment, at least 2 in. in diameter and of extra heavy pipe.

No matter how simple the arrangement of blowoff piping may be, there should always be some provision made for cleaning it out without having to disconnect the pipe. About the simplest arrangement possible is shown in the sketch, where a cross is used instead of the more often used tee. The brass plug C can be removed and a small iron pipe ram forced through pipe A and the straightway valves.

JOHN THORN.

Studies in Human Nature

WHAT A difference there is in men. The other day I had occasion to visit several boiler plants in the vicinity in an attempt to get together some information on equipment I am thinking to install in my plant. I wanted to get several points of view on the subject and find out if possible under what conditions of operation one type of this equipment might possess certain advantages over another.

In the first plant I visited I found the boiler room foreman at his ease reading the morning newspaper and so felt little hesitancy in asking him to give me a few moments of his time. I proceeded, therefore, to ask him a few questions concerning his installation but despite his apparent leisure and want of companionship he was not overly responsive to my queries. He seemed suddenly to be in very much of a hurry about doing something and would give me only the briefest answers, usually nothing more than a "Yes" or "No." It was like pulling teeth to get anything out of him and it required so much energy that I had little left to draw an argument from him. I left the place but little wiser than I came and not much nearer to a solution of my problem. I believe I could have done better had I inspected the installation unassisted, or unencumbered perhaps would be a better way of putting it.

Compare this man with the man in charge of the next plant I visited. Inquiring at the door I was informed that the chief was over at No. 3 boiler. There I found him inspecting some hand hole covers that had been leaking. Seeing me he inquired if he might be of service and then asked me if I would wait a few minutes he would talk to me. After about 5 or 10 min. he came down and escorted me into his office, offered me a chair and asked me what was on my chest. I explained my mission as briefly as possible.

Having thus delivered myself he began to recite his past experience with several types I had in mind and went into rather minute detail discussing the advantages and disadvantages and drawing certain conclusions as to how one system or another might fit in with my plans. He had had no experience with one type I was considering, but his friend, Brown, down state was using this kind of equipment and he told me what he had learned from him on this phase of the question.

When we had finally covered the subject in this way from a distance, so to speak, he took me out in the boiler room for a few close-ups. Here he pointed out why this particular equipment was probably better than some other under the conditions with which he had to contend and how another might be better adapted were conditions different in some respects.

When I finally left I had something to work with

and had come to a fairly definite conclusion in regard to my own problem.

Which of these two men do you suppose will receive the heartier reception should either of them chance to visit me in the future? Which has performed the greater service? Which has done more for his profession? Which will receive the greater cooperation on any problems he may have to solve? This second is the type of man we would all like to know. I would that there were more like him. He is the kind of man who, for instance, writes of his experiences, of difficulties overcome, of new kinks he may have run across for the benefit of his fellow engineers. He becomes widely known and of ever increasing value to his employer. He is the kind of man who progresses farther in the long run.

CHICAGO, ILL. TOM KENNEDY.

Mistakes in Text Books

WHAT SHALL WE do about mistakes in text books? The writer frequently runs across errors in rules and statements that may prove to be more or less serious should they be blindly applied without first carefully checking them up.

Mistakes of this kind should be brought to the attention of the authors or publishers so that steps may be taken to correct them in future issues. The proper way, it seems to me, would be for the author and publisher of the text or hand book to solicit criticisms and to have errors pointed out. Then after a sufficient number of errors have been received, compile an "error sheet" and send it to all the possessors of the book.

Or, probably a less expensive way would be to publish the error sheet in the advertising pages of publications in the fields in which the book is used.

Unless mistakes are brought to the attention of authors or publishers, the same errors are liable to be published in succeeding editions so that the possessor of a first edition who may want a second edition must go over the entire second edition and correct the errors in it that he discovered in the first edition, which makes it very inconvenient. For that reason I often delay the purchase of a second edition of a hand book as long as I can.

Unfortunately it is almost impossible to get out a hand book free from typographical errors, but would it not be worth while for the publisher to make a serious effort at eliminating all errors? The best way to do so, from my viewpoint, is to solicit the aid of all users of the book and to at least be grateful for any such gratuitous assistance received.

Or, should the publisher prefer to pay for corrections, a payment plan might be still better. Let the publisher offer to pay a dollar or two for "every mistake" found. Then in publishing the error sheet the name of the first finder of the error could be given so that others could not claim the "prize"—if it could be called a prize. Offering to pay for mistakes found would probably tend to make both author and publisher more careful in producing the book, would indicate confidence in its accuracy and tend to increase its sale; it would stimulate users of the book to "look for mistakes" and would caution them to be more careful in applying formulas, rules, etc. So far as the writer knows, no book is infallible.

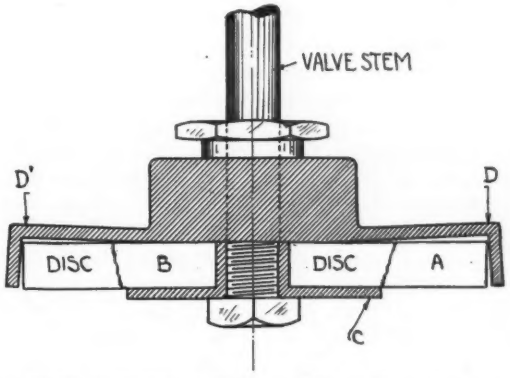
Newark, N. J. W. F. SCHAPHORST.

Effect of Deformed Valve Disc Holder

WHEN ONE of our 3-in. globe valves started leaking, the disc was removed and as the seat appeared to be in good condition a composition disc was put on. This stopped the leak at the time but it started again in a few days. Examination showed the disc cracked as shown at A and B in the accompanying sketch. Another disc was put on but the valve started to leak again in a couple of days. The helper who had renewed the discs stated that they were not cracked when he had put them on.

Before making a complaint to the dealer who had supplied the discs, I thought it better to look further into the matter. Upon doing so I found the disc holder as shown in the sketch. The extent of the defect is exaggerated in the drawing so as to show the deformation more clearly.

The disc holder at DD had perhaps been distorted as shown by excessive force applied when attempting to close



LACK OF SUPPORT AT EDGE OF DISC CAUSES THE DISC TO CRACK

the valve. When I started to work at this plant I had found a defective metal disc on this valve which was so tight a fit in the holder that it had to be cut out. If excessive force applied to the valve wheel on the handle had not caused the trouble, it is possible the helper had done the damage when cutting out the metal disc, although he was positive in asserting he had been careful.

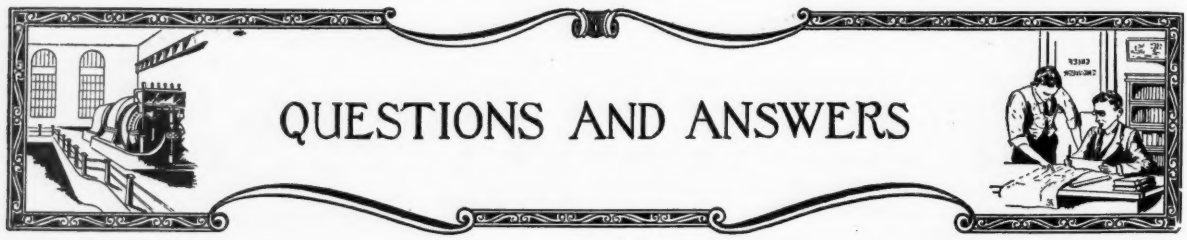
The lesson to be learned here is to use some discretion in closing a valve. Do not force the disc on its seat.

Toronto, Can. JAMES E. NOBLE.

Peculiar Cause of Pump Failure

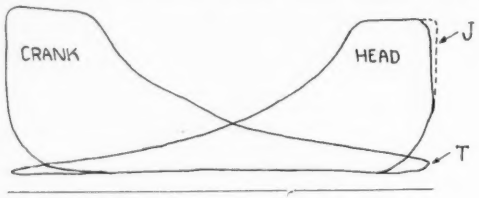
WE HAVE in our plant a standard make of vacuum pump which has been in continuous service for about 5 yr. without giving us any trouble. One morning not long ago it made a stroke toward the head end and stopped dead. We moved the piston back and opened the throttle; it went back to the head end and stopped again. We then removed the steam chest and valve and on examination we found four small rattles that had been left in the steam chest at the foundry. During the 5 yr. of operation they had worn down enough to get into the steam port where they prevented the movement of the valve. We removed these rattles and replaced the valve and chest and since then the pump has been giving us as good service as ever.

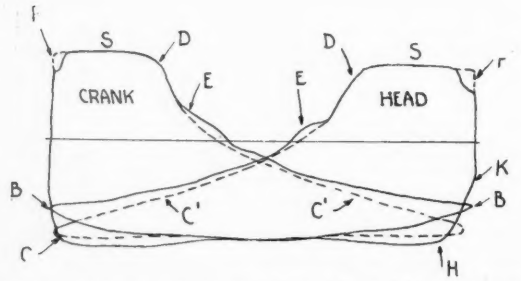
Connersville, Ind. RUSSELL TOWLER.



What Causes the Hook?

In the high pressure diagram of the indicator cards submitted by J. L. in the June 1 issue, the head end admission is slow in opening. The compression line should be vertical, as shown by the dotted line J. This may be due to looseness in the brasses connecting the latch rod with the wristplate and the hook rod to the rocker arm, if it is a Corliss engine, or there may be too much reach of the latch past the latch block, which would allow the





CORRECTED DIAGRAM FROM 15 BY 26 BY 36-IN. ENGINE

piston to travel forward slightly before the latch engaged the block. This looseness causes the valve to open slowly and the line to lean forward. The crank end exhaust valve does not open quite soon enough for free release, causing the little curve at T.

In the low pressure card there is little or no compression on the crank end at G and also on the head end at H. Both low pressure exhaust valves open too late, as seen at B-B. They should open earlier in the stroke and this earlier opening will also cause them to close earlier and give a better compression. It requires more compression for an engine running condensing than one running non-condensing. There is not enough lap on these exhaust valves to prevent leakage into the condenser, though they are almost closed. This would cause the uneven expansion line E-E. The expansion line should follow the dotted line C'-C'. The exhaust valve on the head end closes some time earlier than the one on the crank end, but there is leakage or the valve may be lifting up on a sort of shoulder, then closes at H which causes the compression to rise quickly up to the point K where the admission begins on the head end card, running up to F'. Here the piston is moving forward, and the pressure continuing to rise up to the steam line shows there must be an increase in the receiver pressure after the valve opened or the looseness and wear in the valve mechanism on this side of the engine caused the valve to open slowly or the leakage through the exhaust port to the condenser caused this knocked off corner at F'. The rounded corner at the point of cutoff D-D shows the latch tail plates and trip cam or roller are somewhat worn which causes a slow release instead of a sharp trip, which would make a sharper corner at D-D. On the crank end diagram there is practically no compression and some looseness in the brasses and pins causes the latch to engage the block but before the steam valve can open, the looseness in the connections from this point to the eccentric must be taken up by the travel of eccentric. Steam rushes into the cylinder and the pressure rises to the point F' where it drops back, making a hook until the wristplate has traveled far enough to close the exhaust valve tighter and the steam pressure in the receiver has increased to the steam line S. While this is taking place the piston is traveling forward and leaves the same knocked off corner with a hook on this diagram similar to the one on the head end.

I should take another card from this side of the cylinder and notice if the receiver pressure did not vary about 2 lb. at this point of the piston stroke, then set these exhaust to close earlier so as to get better compression. This will cause an earlier release, more lap, less leakage and will probably shorten the cutoff, giving a little higher and steadier receiver pressure and a better expansion line.

Cambridge, Mass. R. A. Cultra.

Will a Trap in the Return Line Help?

In his question on the use of a trap in a return line, which appeared on page 667 of the June 15 issue, M. O. P. makes the statement that he has frequently found a trap blowing through, even new traps or traps where the diaphragm had been recently renewed. When this condition occurred he found that on tapping the trap lightly, it immediately closed.

This evidence seems to indicate the presence of scale in his system, due to internal corrosion of the piping, or dirty boiler feed, which may have been an accumulation covering a period of years.

If he has no dirt strainers between the ends of his coils and the return traps, I would advise putting them on.

This would incur a considerable expense, but since this is a first cost only, the saving in coal would justify it.

The installation of the traps could be extended over a period long enough, to watch results as each strainer is put on, taking the coils and traps that gave most frequent trouble first and working up to those that gave little or no trouble.

These strainers are provided with a dirt pocket and provision is made for opening them up and cleaning them

out. This should be done periodically, or before the heating season begins.

In regard to his intention of installing a low pressure trap, this would make a bad matter worse but in another way. The leaking traps would build up a pressure in the return lines, during the periods when trap was filling, and would seriously affect the circulation in the system.

Worcester, Mass. LEROY BLAKE.

Operation of Feed Water Heater

ON PAGE 617 of the June 1 issue, R. G. S. has a heater problem. If there is room for a tee on the line to the sewer put one in and connect the pump suction into it. Use the present pump suction outlet for the pump exhaust connection. The pump suction and steam pump exhaust can be changed by bushing one and increasing the other opening. If this is not possible put a tee in the discharge line from vacuum pump and exhaust into that or put a grease extractor on the exhaust from steam pump and cut the exhaust in behind the vacuum pump and run it partially condensing.

Will the water prevent this pump from exhausting? To all intents and purposes, yes. For example, we had a simplex boiler feed pump $5\frac{1}{2} \times 7\frac{1}{2} \times 12$ in. with 1-in. steam line and a $1\frac{1}{2}$-in. exhaust, which ran straight up from the pump 9-ft. and then through a 90 deg. elbow and a short nipple into a 9-in. exhaust line from an engine. Several other pumps also exhausted into the common 9-in. main. As long as this particular pump was kept running everything was O.K. but if it was shut down and allowed to stand long enough for the condensation to fill the exhaust up to the level of the 9-in. pipe, 110 lb. boiler pressure would not start it. This was cured by putting a tee at the bottom of the pump exhaust line where it came out of the pump and connecting in a low pressure trap, which took the water out.

Although it is not good policy to waste steam if it can be avoided, if the exhaust from this particular pump cannot be delivered to this heater anywhere else than where it is now, pipe it out to the atmosphere. What happens is that the water works back against the pump and increases the pressure against which it has to exhaust.

Minneapolis, Minn. FRED S. RUTLEDGE.

Measurement of Oil Viscosity

IN THE article on the measurement of oil viscosity which appeared in the April 1 issue, the statement was made that for the purpose of comparing viscosities of any two oils any simple method of measuring the time required to discharge a given amount through any size orifice under identical head conditions and at a constant temperature. This is not entirely correct. It is true that a fair comparison can be made between two oils if proper precautions are taken to insure the same uniform temperature and to use a glass pipette for all tests. If the viscosity of two oils is being compared by this method, it is necessary to keep in mind that if the oils vary at the temperature at which the test is made, it does not necessarily indicate that they are not the same at other temperatures. For instance, it is possible to take oils both of which have a viscosity of 50 sec. at 210 deg. F. and comparing their viscosity at 100 deg. F. it will be found that one has a viscosity of 200 sec. and the other 350 sec.

The pipette method of taking viscosity is, therefore, only a crude comparison between several oils. In addition, it is impossible to compare the results obtained with any other observer and if the pipette is broken, all previous records are of little value.

The Saybolt viscosimeter is now almost universally used throughout the United States for taking viscosities on oils.

Even if only approximate figures are wanted, a Saybolt instrument should be purchased instead of making an attempt to manufacture one in the laboratory. The cost of the Saybolt instrument may appear high but it will be found that the labor cost in manufacturing one would run considerably in excess of the purchase price because it would probably be necessary to make two or three attempts before even an approximate instrument would be produced. Even then the chances are likely that the instrument would be inaccurate. We say this because we have found that the slightest variations in instruments greatly affect the accuracy of the results.

Viscosity of an oil is not a measurement of its quality. If oils are purchased from a reputable refiner variations in viscosity in the same brand will not occur, except of course, where wrong oil may have been shipped in error.

Viscosity is only one test of determining the uniformity of an oil. It is quite possible that one kind of oil may be of the same viscosity as another but it may be for a different service condition and, therefore, would give unsatisfactory results. One would find in most cases, however, that two oils having the same viscosity but made for different purposes would vary considerably in the other physical tests. Therefore, if one wishes to insure uniformity, it is necessary not only to make the viscosity test but also to make all the physical tests commonly determined on lubricating oils.

PREPARED BY THE TECHNICAL DEPARTMENT OF THE VACUUM OIL CO.

Boiler Capacity for Heating Installation

I AM about to install a boiler for a steam heating system and would like to have an approximate estimate as to what boiler capacity will be required for a gravity return system. G. J. B.

A. One boiler horsepower is equivalent to the evaporation of 34.5 lb. of water per hour, from and at 212 deg. F., i. e., $34.5 \times 970.4 = 33{,}479$ B.t.u. per hr. Under ordinary heating conditions with steam at about 5-lb. pressure and a room temperature of, say, 70 deg. F., 1 sq. ft. of direct cast-iron radiating surface will transmit about 250 B.t.u. per hr. Thus 1 boiler hp. capacity will take care of $33{,}479 \div 250 = 134$ sq ft. of heating surface.

To find, then, the boiler capacity required, it will be simply necessary to divide the square feet of heating surface installed by 134.

Boiler Pulsates

WHAT CAUSES a horizontal return tubular boiler to pulsate in its setting, a kind of breathing action, and when is this occurrence most likely to be noticed? E. E. C.

A. Pulsation of a boiler is caused by weakness and want of steam capacity, also by poor boiler design. It is most noticeable when the boiler is being forced in order to keep the steam pressure at the required point.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

The Need for Optimism Today

It is true that business, speaking generally, is only fair right now. It is true there has been a reduction in unfilled steel orders—wages remain high in some industries—over-development of productive capacity is having its telling effect.

But—there never was a time, at least since the war, when the long-distance outlook for business was more promising that it is today. Never has the United States been more of a leader among nations, politically, industrially, economically. Since 1900 the personnel of manufacturing industries has doubled while the value of the fabricated products is now six times the total as of 24 yr. ago. Industrial activity is steadily moving westward. This stimulates the growth of cities and brings the farmer nearer his market. Wages have increased over 400 per cent since 1880. Since 1885 the proportion of workers under 16 years of age has declined 60 per cent. Mechanical inventions have lifted the drudgery of labor from the shoulders of the workingman and radio is making the transmission of thought and messages a matter of seconds, thus developing greater appreciation and understanding for others' problems.

The American public spends $1,000,000 a day for coffee; $8,000,000 a day for milk; $420,000 a day for electric light bulbs; $16,000,000 a day for insurance policies; $5,000,000 for eggs; $3,000,000 for gasoline; $1,750,000 for newspaper advertising; $3,000,000 for vacation trips and $1,000,000 for new telephones. We, as a nation, purchase 11,000 automobiles every day and require over a million pairs of shoes.

The thing we need to realize is that these expenditures have continued for years and will continue regularly—without regard to temporary business fluctuations. In a few months, or a year at most, we shall have forgotten that there was such a thing as a period of depression or uncertainty. There is no basis for our present day pessimism. Business would be excellent if we would only let it alone.

The Public Usually Guesses Wrong

A man died in Chicago recently who had amassed a fortune of nearly a half million dollars. For years he had gambled on the stock exchange. It was his habit to arrive at his office only after the day's business was well under way. He would then ask his office manager: "What is the public doing today—buying or selling?"

If the majority was buying he would sell; if the public was selling he would buy. His guide was: "Most people usually guess wrong."

The public is mass-minded. Which explains why it is so easily stampeded. It is never difficult to mob-olize a mass-minded group. Pessimism is contagious and invariably swings too far. Ditto, optimism.

During 1918 and 1919 a great deal of Iowa land changed hands at from $500 to $700 an acre—a price at which it was impossible, with all the scientific farming methods taught at Ames, to make 6 per cent on the investment. Today the same land is going begging at $200. The man with a little capital could make money in Iowa land right now—because everybody wants to sell.

When the public wants to buy—sell. When everybody wants to sell—buy. The public "usually guesses wrong."

What Freedom of Speech and Government Ownership Means

The per capita consumption of news print paper in 1920 was:

Russia	6 lb.	Germany	45 lb.
Japan	12 lb.	Great Britian	76 lb.
		United States	150 lb.

Telephone conversations, per capita, were:

Great Britian	18	Germany	52
France	18	United States	160

There are two telephones for every 100 people in Great Britian. In the United States—13.

These two comparisons speak eloquently the difference between free and restricted expression and between government and privately owned public utilities.

Unrestricted dessemination of information makes for greater knowledge and broader views, shown conclusively in the newsprint paper consumption. Private initiative is better than government operation, as evidenced by the number of telephone calls in two countries closely paralleling each other in social, political and moral ideals.

Large or Small Inventories?

We cannot vouch for the authenticity of the report but we have been informed that Mr. Ford is producing in excess of 200,000 cars per month. Also that he operates on an eight-day inventory. That is, he stocks supplies to meet his manufacturing requirements for only eight days in advance.

This seems impossible. It is so uncanny we venture the assertion that the eight-day inventory covers only certain items. However, it shows wizardry at organization. If true in any respect it proves the flivver king a manufacturing genius.

Dealers, jobbers and manufacturers in any line might well cogitate Mr. Ford's success in maintaining small inventories. One of the chief causes for a non-existent surplus is over-buying. The deadly parallel of a non-existent surplus as against Mr. Ford's reputed $428,000,000 teaches the moral of low stock, quick turnover, management. It is better to stock dollars and cents in the bank than goods on the shelves.

Killing the Goose

The Wisconsin Manufacturers' Association recently issued a bulletin entitled: "Wisconsin, Wake Up!!" We quote:

"The story of two Wisconsin industries now in the public eye ought to strike home to every citizen of Wisconsin.

"The Palmolive Company of Milwaukee and the Nash Motors Company of Kenosha are two of the largest manu-

facturing industries located in our state. They have become national institutions with over 95 per cent of their product sold outside of Wisconsin. They bring millions of dollars within our borders to be distributed in wages, materials, transportation, construction, which in turn means purchase of food from farmers, clothing, shelter and fuel from retailers and services from professional men.

"The Palmolive Company of Milwaukee from small beginnings has attained a world market which justifies a $4,000,000 annual appropriation for advertising its products. It has established branch factories in other states and built up its home organization in Milwaukee as a Wisconsin corporation. Before the last session of the legislature rumor was persistent that extensive additions were to be made to the home factory. What has happened?

"The general office has moved from the state. The Wisconsin corporation has become a branch factory. The men who, with the abilities and capital, were in a measure responsible for the success attained, are no longer residents of Wisconsin. Wisconsin loses the right to assess an income tax against the major portion of its earnings. Wisconsin loses the right to assess an income tax against the earnings of the non-resident officers while living, and substantial inheritance taxes when dead. Most of all Wisconsin loses the initiative and voluntary support of public enterprises by able men who can help to make our state prosper.

"The Nash Motors Company of Kenosha is the reorganization of a corporation of average proportions by Mr. Nash and the officers of the new company who came into this state just a few years ago. By their genius and resources they have developed a remarkably successful business, the benefits of which have extended to all parts of our state.

"At present they are among the heaviest tax payers in Wisconsin. Their tax burden is several times what it would have been if located in Michigan, the home of their principal competitors.

"These men now resist the imposition of added burdens to industry in Wisconsin, calling attention to our present unfavorable laws compared with other states. For their pains, they are branded by men in political position as unpatriotic and tax dodgers.

"Mr. Nash and his business friends do not have to stay in Wisconsin. It would be mighty easy for them to follow the footsteps of Simmons and Palmolive and make their Wisconsin plants branch factories.

"Do we want Wisconsin industries to become branch factories owned and operated by non-resident stockholders? That's just the way we are headed. Let's turn around. Wisconsin, wake up!"

We hope the demagogues in Washington read this that they may realize the effects of unwise legislation and excessive taxation.

Advertising

Our prehistoric forefathers would have perished from the earth had they not known the science of reading advertisements.

The cave men didn't know much about underwear, radio, or bacon done up in a fancy box, but they did have to eat. And the one who could follow the tracks of the game he hunted, or read the meaning of a twisted leaf or a broken twig, was best off in life.

There has been something of an evolution in advertising during the last few thousand years, but the principle remains the same. The consistent reader of advertisements usually gets most from life.

Buy Your Coal Now

Store your winter requirements of coal before September first. Today, mine operators are selling their product at a virtual loss. There is nothing to be gained by delaying the purchase of coal until chilly weather sets in.

Production of Electricity Increased

WITH AN INCREASE in the total annual electric power production of 28 per cent for the year 1923 as compared to the production in 1920 comes the announcement from the Geological Survey, Department of the Interior that the consumption of coal and its equivalent in other fuels per unit of power has been decreased 20 per cent during the same period. The increase of production by water power for this period was approximately 20 per cent, whereas the increased production by the use of fuels alone was about 33 per cent.

The important point to be emphasized is that although the annual power production by fuels increased 33 per cent in 4 yr. the consumption of coal and its equivalent in other fuels increased but slightly over 5 per cent. Expressing this in pounds of coal per kilowatt hour it is found that the consumption in 1920 was 3.0 lb. per kw.-hr. and in 1923 it was 2.4 lb. per kw.-hr. or a reduction of 20 per cent. The consumption of coal and its equivalent in other fuels for 1923 was 43,522,000 T. Had the rate of consumption per kilowatt-hour remained the same as it was in 1920, this total coal consumption would have been increased by 10,600,000 T. In other words our national fuel resources have been conserved by that amount for the year 1923 alone.

Carrying the analysis still further by a consideration of the increase in consumption of coal, oil, gas and wood fuels, it is found that the consumption of coal alone for 1923 increased 4.9 per cent over 1920; oil consumption increased 11.9 per cent; the use of gas increased 27 per cent and the number of kilowatt-hours produced with wood as fuel increased 49 per cent in 1923 over that produced in 1920.

These figures are based upon the Geological Survey's monthly reports on the production of electricity received from about 4000 electric-power plants generating electricity for public use. The output of central stations, municipal plants, plants generating electricity for the operation of electric railways and electrified steam railroads, Bureau of Reclamation plants, and also the portion of the output of a few manufacturing plants that is sold for public use are included. The output of plants whose monthly production of electricity is less than 10,000 kw.-hr. is not included, as most of these small plants do not have recording meters and are therefore unable to make accurate reports. The combined output of these small plants is much less than 1 per cent of the total for the United States.

At the present time the total capacity of generators in the power plants whose output is included in the monthly reports is about 17,800,000 kw.-hr.

EDITORIAL COMMENT

Electrical and Steam Engineering Meet in the Power Plant

It has not been many years since there was a definite line of demarcation between the steam and electrical end of power plant work. The electrical man had his plant design and operating problems and the steam man dealt with design and operation of apparatus for developing and utilizing steam.

Today, however, this distinct division of work does not exist. Electrified auxiliaries, remote control of operations by electrified means, including in many cases both heat balance and combustion, have brought the steam and electrical problems into intimate contact.

As a result power plant designers and operators have come to look upon the problems of power production as a unit rather than as two isolated branches of engineering art. For that reason the man whose work deals primarily with the electrical side of the station must be familiar with steam problems. In the same way the steam man must have a thorough knowledge of the electrical equipment which affects operations on the steam side of the generating equipment and should also take more than a passing interest in electrical equipment beyond the generator.

There is only one road to successful station design and operation and that is to have a complete understanding of the station problems in their entirety.

The Squirrel Cage Repulsion Motor

High inductance in an electric circuit we usually associate with thoughts of low power factor and in these days when power contracts contain penalty clauses for low power factor, high inductance therefore is a good thing to avoid. It seems more or less paradoxical therefore to learn that by adding a highly reactive squirrel cage winding to the commutated winding of a single phase motor we can produce a machine whose power factor at full load is close to unity. In other words, by simply adding a highly reactive winding to a machine with an inherently low power factor, the power factor can be raised considerably.

To the uninitiated this may sound mysterious but a reading of the article, "A new type of single phase motor," appearing in this issue will reveal the fact that no principles of electrical engineering are violated and that the results are strictly in accordance with theory.

Another interesting fact regarding the performance of this new motor is that it has the characteristics of a shunt wound motor over the running range and those of a series motor during the starting and accelerating period. These characteristics together with that of low power factor at full load, naturally are desirable and should do much toward making this motor popular.

For years, in fact ever since alternating currents came into general use, various attempts have been made to produce a satisfactory single-phase motor. Elihu Thomson's repulsion motor was a pioneer in this field and was a good machine in many ways but had a number of mechanical drawbacks. The new motor described in this issue is a combination of the repulsion motor and the squirrel cage induction motor, and for this reason has been referred to as the squirrel cage repulsion motor.

While this new motor is not, as Professor Karapetoff pointed out at the recent convention of the A. I. E. E., all that could be desired in a single phase alternating current motor, it is a step in advance and its use will undoubtedly lead to further development in alternating current motors.

Analyze the Complete Power Problem

Most of the poor examples of industrial power production methods in use today are the direct result of lack of foresight and the refusal to seek and accept expert advice on the subject.

As has been the case with most of our successful plants, their start was made in a small way. Capital expense was a matter of much greater importance at the beginning than it was after they had become well established. This may have resulted in a legitimate excuse for the first power units to have been of small capacity and therefore possibly not of the greatest efficiency.

As prosperity envelopes a plant and the volume of business increases, more power is required, but too often the question of power is not given the attention which it deserves. It is not studied from the viewpoint that power equipment manufacturers are constantly putting improved equipment upon the market and further that it is not only possible to make economies in the generation of power but also in its distribution and its utilization.

The most simple application of power is to locate the generating units close to the points where their power is to be used. This method in itself requires no engineering experience of any importance nor does it allow of any planning for future requirements. It simply develops into a crude method of meeting the power demands as they increase from month to month or from year to year. This method often leads to the purchase of cheap or unsuitable equipment. This places the management in an unfavorable position because it leads one to the frank supposition that if one productive department is poorly managed can it be possible that any of the other departments are managed any better?

One circumstance which is conducive to the neglect of power production and use is that competent engineering ability is not considered necessary during the early stages of plant operation. Rule of thumb and guess work methods then continue in practice until the power question has gotten completely away from the management and it is found that not only fuel bills are unreasonably high but that the man power required to operate and maintain the

entire power system is an outrage in the face of productive methods which are supposed to have eliminated waste motion and labor hours on the finished product.

It means that the management stands indicted because with high production costs in the power department it is practically conclusive proof that the costs in other departments can and should be cut.

One unusually good example of what good management can do is the development work recently undertaken by the Crossett Lumber Co., described in this issue. That company tore out 24 boilers which were scattered all over the lot and at the same time constructed a 3000-rated b.hp. plant which is fired by waste fuel. They then made a study of mill drives and electrified the mill, which necessitated installing generating capacity to the extent of 5250 kw.

Centralization of power production and the good design of the entire system cut the number of men on the power plant pay roll from seventy to nineteen. This is but one of the results of constructive planning and thinking and it is right in line with what can be done in a great many other plants which are still operating under the disadvantages of the old order of things.

Meeting Emergencies Is the Test of Good Management

When the work of an organization is going along smoothly, when the individual units of the organization are functioning in synchronism and when the results achieved are commensurate with this clock-like precision, it is quite natural to assume that perfection has been reached. Unfortunately, however, this type of perfection is not the full measure of the abilities of an organization or an individual. Of even greater importance is the ability to meet the unusual and emergency conditions which arise.

In the management of a power plant, or a power system, this ability to meet any emergency is not the result of foresight on the part of one man, but it is brought about, rather, by making the problem of meeting emergencies a part of every position. When lightning strikes, where the tornado sweeps its path, where the flood comes, or the steam pipe breaks, it is not what the general manager, or the power superintendent, or the chief engineer would do if present but what the individual on the scene of action will do, that counts in the final reckoning.

In some organizations, when emergencies arise, all relief methods and rehabilitating work must await one or two directing personalities. The men involved are at a loss as to what should be done. As a result the damage grows, service is interrupted longer than necessary and the final toll is much greater than it should have been.

It would seem that one of the fundamentals of good management should be to lay even greater recognition to those men who show their abilities under stress of circumstances. This means that every man in the organization should know what should be done to meet unusual situations in his own work or in the work of those around him. It means that the organization should encourage initiative under such conditions and should uphold judgments made under pressure.

Good management, whether it be in the main office, turbine room, boiler room, coal yard or distributing system, calls for just as thorough a study of what may happen as what is happening. The final test, then, will lie in the actions and reactions of the individuals when meeting the next emergency.

Co-operation Between Engineering Societies and Engineering Schools

An outstanding event in the field of engineering education during the past year has been the inauguration by the Society for Promotion of Engineering Education of a comprehensive project of investigation and development of a plan for furthering the active co-operation of the faculties of engineering colleges, the professional societies, the employing industries and other agencies.

In recent years there has been a strong trend toward standardization in professional education for medicine, dentistry and law. In each case the respective groups of schools and related national professional associations have set up joint agencies of educational standardization. This movement has been closely related to the comprehensive investigations conducted by the Carnegie Foundation for the Advancement of Teaching and has been productive of important gains in the standards of educational preparation for these professions.

While it is apparent that engineering occupies a professional status, dissimilar in important respects to the older, highly individualized professions of divinity, medicine and law and that the formal relations between education and professional fields do not necessarily constitute precedents of compelling logic, it is equally true that the national engineering societies might lend a far greater body of support to the engineering colleges without any trespass on their independence.

It is gratifying to know, therefore, that the national engineering societies are taking an important part in the proposed investigation.

At the 1923 convention, the Society for the Promotion of Engineering Education voted to invite the four founder societies to appoint advisory councillors in education who should confer with the Board of Investigation having oversight of the general project. This invitation was accepted by all of the four societies and the conference group has now agreed to sponsor and direct studies of a number of subjects.

Some of the subjects, the study of which the conference group has agreed to sponsor are as follows:

The criteria of professional status, with a view to defining more accurately the status of the professional engineer.

Minimum standards which may properly be established for the recognition of any institution as an engineering school or any course of study as an engineering course.

Sanctions concerning the normal length and the degree of specialization of engineering curricula to which the societies represented may be willing to give support.

A survey of the occupational demand for engineering graduates in the more distinctly professional fields as a complement to the surveys of demand in industrial fields now being undertaken.

This project is a step in the right direction, its hearty support will do much to give the engineering profession its proper status in our social organization.

World's Delegates Discuss Power Problems

HIGH LIGHTS FROM THE WORLD POWER CONFERENCE AT WEMBLEY, LONDON, ENGLAND. BY ARTHUR L. RICE

OPENED by an address from H. R. H., the Prince of Wales, who is president of the British Empire Exhibition, the Conference devoted its sessions to a review of the power resources of the world in fuels, water power, wind power, tides, steam wells, also to a consideration of how these resources may best be conserved and utilized.

Two days were devoted to the resources of the various countries and to the economic and financial aspects of power development and distribution. Details were then taken up of Preparation of Fuels, Steam Generation, Steam Turbines, Gas Making, Combustion Engines, Development of Water Powers, Operation of Power Plants, Transmission and Distribution of Power, Power Utilization in various industries and for Transport and finally the questions of Technical and Commercial Education of Power Plant Engineers and Managers, also the matter of Engineering Research in the Power Field.

Opening Session

This meeting was called to order on June 30, by the Earl of Derby, President of the Conference, who introduced the Prince of Wales. In his speech the Prince welcomed the delegates and suggested that the Conference might well result in combining the knowledge and judgment of the world for the solution of problems of science, research and economic progress. Industrial progress, conservation of fuel and energy, standardization in design and manufacture have largely been worked out by each country in isolation. A study of our present industrial structure, the part that power plays in that structure, and how power may be so utilized as to remedy the weaknesses of the structure will be of great benefit and a worthy object for world cooperation. While individual views may not agree, discussion in an atmosphere of cordial appreciation will do much to tighten those personal contacts which make for progress. Finance, science and research are universal, but utilization of results derived from these activities is not and in this disparity lies one of the greatest obstacles to progress. From the Conference will result a policy applied internationally which may contribute largely to harmony and economic progress of the world. International cooperation may emerge from the realm of the ideal into the realm of practical helpfulness as a result of the deliberations of the Conference and "I sincerely trust that all success will attend them."

Sir Joseph Cook, in replying for the British Dominions, asserted that we need a balance of accounts more than a balance of power. At present the development of power is not sufficient either for the needs of the individual or of the State and we need to seek and develop new sources which may be had if we knock long enough at the door of Nature.

Ing. Guido Semenza of Italy said that it was probably the first time that one man had dared to speak for all the nations of continental Europe. He acknowledged the Prince's welcome and pointed out that ancient civilizations failed to progress because they did not discover new sources of power.

O. C. Merrill of the United States Federal Power Commission called attention to the meeting of the Conference for consideration of power as a means to human progress, not for national aggrandizement. Electrical energy is the greatest power ever placed in our hands to relieve mankind from the bondage of toil. It is only 160 yr. since Watt gave us the power of steam and only 40 yr. since electricity became a tool of mankind. The Conference is a meeting of the World free from race, boundary, national or creed restrictions, one of the contacts of peoples that is more needed and more helpful than contact of governments. By the use of power, human labor can be reduced so as to give the leisure needed for developing intellectual capacity and thus move for the peace of the world and the welfare of all mankind.

M. Guillaume, speaking for France, said that modern power is engaged in a struggle with matter, in which matter is being gradually overcome. In many older countries, the earth has been the chief source of power, but in mountainous countries, which have developed later, water power is found which is now proving a compensation and the conference can be greatly useful in contributing to the solution of the power problems of those countries.

World's Power Resources

In the first day's technical sessions resources of the various countries were summarized in fuel deposits, hydraulic power and other forms and a survey given of the rate of use and of waste of those resources. While coal in known deposits is available for many centuries, the rate of production has doubled in 20 yr. and reached 1⅓ billion T. in 1913. Europe's coal is being rapidly exhausted and elsewhere the best supplies are being depleted. The United States and Canada must be regarded as the world's storehouse for future supplies of coal.

As to water power, in Great Britain and Ireland 250,000 of a possible 800,000 hp. is now being used.

India has enough water power to meet all her needs for a long time ahead. In Canada, 98 per cent of the electrical power is from hydraulic plants. European countries have developed their water powers rapidly since the war because of the high price and scarcity of coal. The thought was advanced by W. S. Murray that availability of power to all who need it is more important than cost, since in most industries the power cost is only 4 to 5 per cent of the total cost of the product. Continuous power should be attainable by all who can use it. This idea has been taken up by New Zealand and by Norway which are working toward a system which will furnish power to villages as readily as to large centers because the more remote communities need power to supplement their less man power and the ability to get power everywhere for small industries will help to check the flow of population to industrial centers.

Based on all industrial and domestic use, it is estimated that 1/5 hp. is needed per inhabitant or 4 to 5 hp. per household. To get universal power it is necessary to have a wide distribution system and in these plans the system has been the first consideration, planning to give the villages electricity at the same cost as to the dweller in a city. Development of power resources is then worked out to meet the requirements of the system. In this connection the possibility was brought out by Mr. Olmstead of developing small powers, 15 to 100 hp., for local use at less cost per horsepower than the development and transmission of large powers, $100 to $200 per hp. for the small plant and $250 to $750 for the large plant. Also, for steam plants, Norway is using a heat storage system which makes it possible to run boiler plants at 100 per cent load factor and thus reduces the cost to the consumer by 60 per cent.

New Crawling Crane Has Wide Field of Application

FOR HANDLING COAL and for general utility purpose around the power plant the crawling tractor crane has found considerable favor. The crane illustrated herewith is a new 10-T. crane known as type D recently developed by the Industrial Works of Bay City, Michigan. This is a new design and embodies some new engineering features. Among other features, perhaps the most important is the independent control of the traveling, slewing and hoisting motions. These motions may be utilized in a variety of combinations which are said to result in a greatly increased speed and efficiency of operation. For instance, the hoisting and slewing motions may be combined in bucket work for operation at high speed and when traveling, the boom may be swung in any direction to clear obstructions. Slewing in either direction is accomplished without reversing the engine by means of a double friction clutch and a train of bevel and spur gears. A slewing brake holds the boom securely with a suspended load in any position. When operating on uneven ground, this brake eliminates any possibility of sudden rotation with its usual disastrous results. The vertical slewing shaft is located accessibly at the front of the crane close to the base of the boom and since the power is transmitted at this point, there is no great slewing stress carried through the revolving frame.

The entire upper works rests on a rotating steel base, which insures rigidity and alignment. This base rotates on four conical steel rollers which are easily accessible and which may be taken out without removing any of the parts or jacking up the crane. Heavy steel side frames which carry the shaft bearings are bolted to this rotating bed. These bearings are arranged on the outside of the frames so that any shaft may be easily removed without displacement of other parts. All running bearings are provided with replaceable bronze bushings. Wearing surfaces of all thrust bearings are separated by bronze washers and bronze collars are placed behind each bevel gear. All gears in the upper works are of cut steel. All oil pipes lead to the operator's platform and the lubrication is accomplished by a pressure system. Clutches controlling the various motions are of a new friction type which are said to engage smoothly and without shock.

10-T. INDUSTRIAL, CRAWLING TRACTOR CRANE

Tractor shoes are close fitting, smooth surface steel and they operate over adjustable idle sprocket bearings which take up the slack in the tractor belt. Five large size rollers of 25 in. diameter on each side decrease traveling friction and keep the bearings high up out of the dirt. The steel bed plate mounted on the car body is cast integral steel with a circular roller path and external slewing rack. A steel hollow center post is pressed under heavy pressure into this base plate, taking all unbalanced stresses and forming a center of rotation for the superstructure.

This crane has two traveling speeds and reversal of direction is accomplished by reversing the engine. Steering while propelling is accurately accomplished from the operator's platform through friction clutches and brakes controlling each tractor belt. Either belt may drive, coast or be held by brake in any degree to negotiate as sharp or wide a turn as desired. This propelling and steering mechanism is one of the exclusive features of this type "D" crane. It enables the operator to propel and steer the crane independently of all other motions with the boom in any direction. It is especially powerful, enabling the crane to travel up steep grades and over rough ground. Propelling up an incline skidway onto a flat car for transportation is very easily done. Other exclusive features are the automatic double hoisting drums which provide automatic control of the bucket during operation. Both drums provide enough rope pull as required for dragline and hoisting purposes. The feature of hoisting the bucket

open on the auxiliary drum greatly increases the output of the crane and makes operation much simpler. A radius varying appliance consisting of bronze worm, worm wheel and drum, and controlled by friction clutches and semi-automatic brake, raises or lowers the boom when loaded to its maximum capacity. Levers actuating all motions are conveniently placed in two rows in front and alongside of the operator's platform which is located on the right hand side with a full view of the work being done.

The new Industrial crane is built for either steam, electric or gasoline power. The steam crane has two horizontal, double acting cylinders 6 in. diameter by 8 in. stroke. The engine is equipped with a simple radial type reversing gear, by means of which loads may be lowered and the hoisting line played out by power. Cylinder and crosshead guides are cast in one piece and bored at the same setting, thus insuring accurate and permanent alignment. The crane is extremely versatile, operating with clamshell or dragline bucket, electro-magnet, hook and block or grapple. It is readily convertible into a shovel or a pile driver. The makers are confident that their new crane will supply a demand for a general utility crane of small capacity sturdily built.

Improved Helical Movement for Recording Instruments

INTERESTING new developments in recording instrument construction have recently been announced by the Foxboro Co., Inc., Foxboro, Mass. An improved actuating movement of the helical tube type has been

FIG. 1. OVERLOAD TEST OF THE HELICAL TUBE

produced, the secret of which lies in a new method of drawing, shaping and tempering the tube. This method makes possible a tube that is permanent in calibration. It has also been found possible to dispense with the adjustments required in most movements of this general type. These tubes have been so perfected that every tube has known characteristics. It is said to be possible to substitute one movement for another without recalibration.

Another feature of the helical tube is its strength, and as a result it may be subjected to excess pressures that carry the pen beyond the outer edge of the chart. The test pictured in Fig. 1 is an interesting proof of the foregoing statement. A 12-in. chart was placed on the regular 8-in. recording gage and the pressure raised until the pen moved to the outer edge of the 12-in. chart. This is

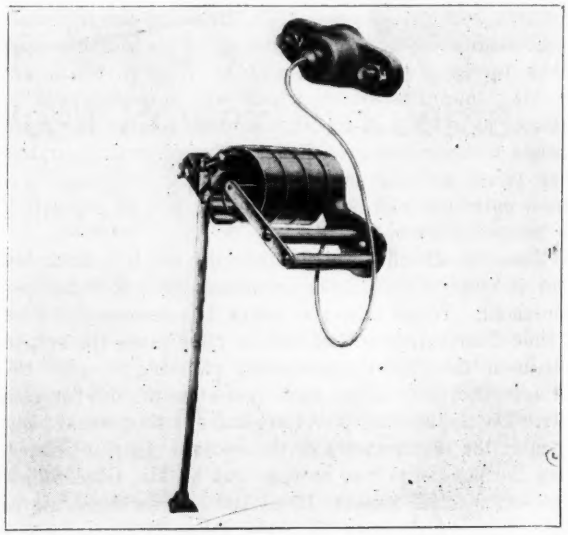


FIG. 2. MOVEMENT IS SAID TO BE SO ACCURATE THAT REPLACEMENT CAN BE MADE WITHOUT CALIBRATION

equivalent to an overload of 100 per cent. The chart record shows that when the pressure is reduced to zero the pen returns to zero, showing that the tube has not set.

Referring to Fig. 2, it will be noted that the construction provides a fixed axis of rotation for the pen arm so that it always follows the arc of the chart. This adds to the accuracy of the instrument. It is said that the accuracy of the improved helical tube movement is within 1 per cent of total scale reading at all points of the scale and for all scale ranges.

Technical Program of N.A.S.E. at National Meeting

THIS YEAR'S annual convention of the N.A.S.E. will be held at Grand Rapids, Mich., from Sept. 8th to 13th, at which time there will be presented a number of technical and welfare topics. The program, which has just been issued, shows the following interesting subjects which are to be covered:

Economic situation in some of the European countries as they affect America. By C. M. Ripley of the General Electric Co. This talk will be fully illustrated by a great number of lantern slides. Following this talk will be four motion picture reels showing electric motor construction, the construction of an electric light socket and the evolution of illumination.

Changes which have taken place and the progress which has been made in the development and transmissions of power during the life of the N.A.S.E. will be reviewed by F. R. Low, Pres. of the A.S.M.E.

Applications of pulverized fuels to up-to-date power plants will be the subject of a paper by Frederick A. Scheffler, of the Fuller-Lehigh Co. Chas. H. Smoot of the Smoot Engineering Corp. will give a paper on automatic combustion control systems. Large Unit boilers operated at high ratings will be the subject presented by Edgar Kidwell of the Kidwell Boiler Co.

The Diesel engine will be covered by two papers, the one by L. H. Morrison on the subject "The Diesel as a Prime Mover" and the other by Louis R. Ford, of the Morse Dry-Dock Repair Co., on the subject "The Diesel Engine Power Plant."

Two papers will be presented on the subject of power plant instruments, E. G. Bailey, Pres. of the Bailey Meter Co. will talk on "Up to Date Boiler Room Instruments" and J. M. Spitzglass, M.E. of the Republic Flow Meters Co., will talk on the development, history and operation of electrically operated flow meters.

Val. A. Fynn, Cons. Eng., will give a 30 min. illustrated talk on the "New Type of Synchronous Induction Motors," and Halbert P. Hill, Cons. Eng., will review the developments in ice-making and refrigerating plants.

New Dial Thermometer for Industrial Use

SEVERAL features of interest are incorporated in a new dial thermometer now being built by the Moto Meter Co., of Long Island City, N. Y. In this instrument the pointer is connected direct to the Bourdon coil, thus eliminating an intermediate rack and pinion movement. The arbor on which the pointer is mounted rotates on a bearing and is the only movable part. The pointer is riveted instead of being screwed to the arbor and accordingly cannot work loose.

ALCOHOL UNDER PRESSURE IS USED IN THE CAPILLARY TUBE

Another point of interest in the design is the use of capillary tubing, known as Schlaich's star shaped tubing. By running the tubing through V-shaped rollers, the walls are pushed inward, forming a tube of star-shaped section, with a diameter between 0.006 and 0.007 in.

Treated alcohol is used in the capillary. When the bulb is subjected to heat or cold the alcohol column expands or contracts, causing the Bourdon coil to wind or unwind and in so doing, to move the pointer across the dial. It is said that the advantage of the special capillary is due to the fact that the alcohol column is so small in diameter that it is unaffected by temperature influence through which it may pass.

There is also a compensating device in the Bourdon coil to offset the temperature of the atmosphere surrounding the thermometer proper.

Non-ferrous metals are used throughout in order to render the thermometer immune to the action of dampness, gases, fumes, etc. The case and bracket are aluminum. Eleven dial ranges are built, covering from—40 deg. F. to 500 deg. F. in dial sizes of 6½ and 5 in.

Lead Peroxide Pellets Used in Lightning Arrester

A NEW TYPE of lightning arrester now on the market is a modification of the cell type of oxide film arrester, developed in 1915 for large stations and large outdoor transformers. At present it is designed for use with the more common distribution voltages.

PELLETS ARE COATED WITH LITHARGE POWDER FORMING AN OXIDE FILM

In this pellet arrester, lead peroxide is formed into small pills or pellets about 3/32 in. in diameter. These are coated with litharge powder, forming a film similar to the varnish film on the cell type of arrester. The pellet is thus a miniature cell, consisting of an oxide film and an active internal filler. These litharge-coated pellets are placed in a porcelain tube and assembled in good electrical contact with metal electrodes at each end of the column. Between the line lead and the pellet column is a small series gap assembly which isolates the pellets from continuous application of dynamic voltage but which allows discharge to take place at a definite voltage above normal.

This new type arrester, which is manufactured by the General Electric Co., is built for voltages from 300 to 15,000.

Death Closes Career of B. G. Lamme

ON JULY 8 the engineering profession lost one of its leading electrical authorities in the death of Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Co. He was 60 yr. old.

Mr. Lamme was closely associated with the late George Westinghouse, who perfected the alternating current system, by which electricity could be transmitted over great distances economically. Mr. Lamme then perfected railway and industrial motors and synchronous converters to make this alternating current useful at any point.

His most spectacular achievements were the designing of generating equipment for the World's Fair in Chicago in 1892; 5000-hp. generators, a world's record at the time, when Niagara Falls was first harnessed for waterpower; generating and motor equipment for the first big railway electrification, that of the New York, New Haven & Hartford Railroad; the present day single-phase alternating current, high voltage railway system, which is responsible for most of the railroad electrifications; the design of the most successful synchronous converter ever used; and the single reduction gear street car motor, which though designed in 1890 is the type still used on street railway systems.

An outstanding trait in Mr. Lamme's character was his interest in young engineering students. For years he made a study of the young, technical graduates who entered the Westinghouse organization, analyzing their abilities and characteristics to adapt them to the work to which they were best fitted. He maintained a design school for these men, in which he gave actual instructions, so that today the methods and knowledge of this great genius have been passed on to the vast Westinghouse engineering body and will stand as an inheritance to these engineers in years to come.

Mr. Lamme was born on a farm near Springfield, Ohio, Jan. 12, 1864. He entered the Ohio State University in 1883 and was graduated in mechanical engineering in 1888, having been out of school during the year 1886-1887, on account of his father's illness and death. He had but little opportunity to study electricity, as there was no electrical engineering course at that time. He had, however, taken a great interest in the subject and picked up all the information he possibly could.

Motor and generator design in those days was mainly a matter of "cut and try," of experiment pure and simple. Albert Schmid, at that time superintendent of the Westinghouse Co., felt that electrical phenomena must be subject to natural laws just the same as materials are. So having heard of young Lamme, whose greatest delight was to "figure," he gave him the task of trying to discover these laws and devise methods of calculation of electrical machines in accordance with them. His success in that line might be described as the foundation for the success of the company and it has influenced and exhilarated the development of electrical apparatus the world over. His success is also attested by the fact that more than 150 patents have been granted to Mr. Lamme, individually.

Annual Meeting of A. S. M. E. to be Held Dec. 1 to 4

FROM Dec. 1 to 4, the Forty-fifth Annual Meeting of the American Society of Mechanical Engineers will be held in New York. During the same week the National Exposition of Power and Mechanical Engineering will be held in the Grand Central Palace.

At the present time the technical program is well under way and the various Professional Divisions have submitted their tentative programs. The authors are at work on their papers which must be in the hands of the publication department during September. A joint session of the Safety Codes Committee with the American Society of Safety Engineers is under consideration. The topic for this will be Mechanical Design for Safety.

As in previous years, the power phase of the program will have its usual strength. There will be a session on Oil Burning in which the Fuels Division will co-operate with the Power Division. This session will treat of marine practice, stationary practice, and the hazards of storing oil. The session on Steam-Power Problems will include a paper on Resuperheating in the Steam Turbine, and a review of recent achievements in burning pulverized fuel. The Power Division will also hold a Hydroelectric Session at which some recent results in draft-tube analysis will be presented. The Oil and Gas Power Division will devote its efforts to a session on the Solid Injection Oil Engine and Its Use for Marine Work.

Lorain Plant Survives Tornado

CAN YOU imagine what damage a wind can do when it becomes strong enough to pick up steel beams 50 ft. long and carry them hundreds of feet—when it picks up automobiles bodily and throws them onto housetops—when it demolishes brick and masonry buildings and makes kindling wood of wooden ones—when it lifts concrete walks and throws them out into the street?

Such were the effects of the disastrous tornado which visited Lorain, Ohio, on Saturday night, Aug. 30, and yet the Edgewater plant of the Ohio Public Service Co. (described in the Nov. 15, 1923 issue of Power Plant Engineering) is still running. True, one 275 ft. brick smokestack was blown over, a steel substation was wrecked and the parapet of the plant was blown over on to the roof. But the plant, which is built upon a foundation down to bedrock, still stands, practically unharmed and supplying current.

Many poles were blown down all over the city but by seven o'clock Saturday night, men and material were on their way to Lorain from the other more fortunate cities in which the Ohio Public Service Co. operates, to start the work of rebuilding. By dawn on Sunday, service was restored to the hospital, dairies and essential industries. By Sunday night flood lights and strings of lamps across Broadway, enabled the relief work to proceed through the night. By Monday night, service was available in nearly all parts of the city.

Transmission of Pictures by Electricity

ONE OF THE most interesting features at the annual convention of the American Institute of Electrical Engineers held at Chicago recently was the demonstration of electrical transmission of pictures at the offices of the Illinois Bell Telephone Co. The apparatus used in this demonstration had been installed at Chicago for receiving the photographs of the Democratic Convention sent from New York City. It was, in fact, the same equipment which had previously been installed in New York for

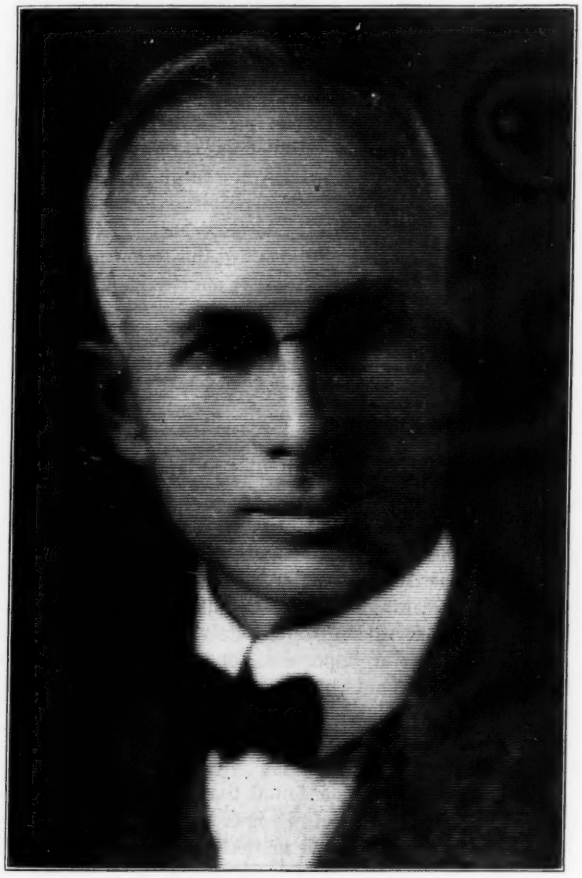


FIG. 1. PHOTOGRAPH OF PRESIDENT RYAN OF THE A. I. E. E. TRANSMITTED BY WIRE FROM NEW YORK TO CHICAGO

receiving the photographs of the Republican Convention held at Cleveland some time before.

Although this apparatus was the first to be used in transmitting photographs over wires on a commercial scale, the principles involved in its construction are not new and have been known for some time. The perfection of the apparatus is due largely to the development and perfection of certain devices, such as vacuum tube amplifiers, photo electric cells, and synchronizing equipment which heretofore have not been available. These devices, which have been used widely in the telegraph, telephone and radio fields, have merely been readapted to this new use. The development of the equipment itself however, is the result of the division of research of the American Telephone and Telegraph Co.

A diagram illustrating the principles of the process is shown in Fig. 1. The heart of the system is the photo-electric cell. This is a small vacuum tube which has the property of varying the electric current through it in direct proportion to the intensity of light falling upon it.

This cell is placed inside of a revolving glass cylinder similar to the cylinder on a dictaphone machine, around which the film to be transmitted is wrapped. The cylinder advances parallel with the axis a distance of 1/65 in. with each revolution in the same manner as the cylinder on a phonograph. A small but intense beam of

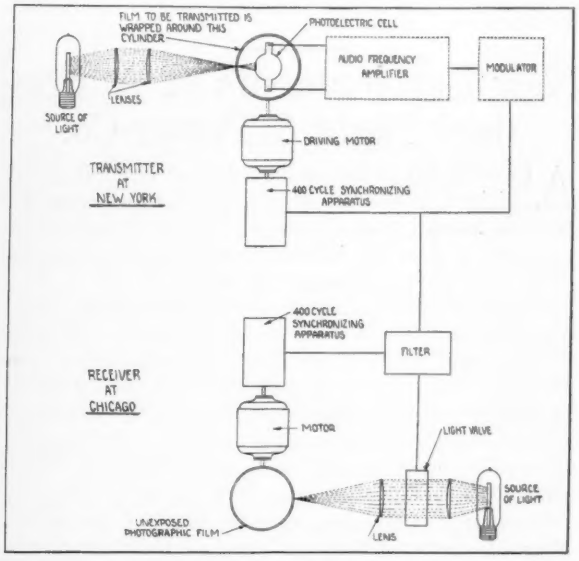


FIG. 2. DIAGRAM SHOWING PRINCIPLES OF ELECTRICAL TRANSMISSION OF PHOTOGRAPHS

light is focused through the film on the photo-electric cell within the cylinder so that as the cylinder rotates and advances, each minute portion of the picture in turn affects the intensity of the beam of light reaching the cell. It is apparent, therefore, that the current through the cell will vary in exact accordance with the light and dark portions of the film.

This current is amplified by means of an ordinary audio-frequency amplifier, such as is used in radio work and is then passed through a modulator, where a 1000 cycle current is modulated in accordance with the variations of the picture current.

At the receiving end, the 1000-cycle modulated current passes through what may be termed a light valve. This is an electromagnetic device which causes a beam of light passing through it to vary in exact proportion to the wave shape of the modulated current. This beam of light is focused upon an unexposed photographic film wrapped around a rotating cylinder similar to the one used at the transmitting end.

The cylinder at the receiving end rotates in synchronism with the transmitting cylinder and as each portion of the unexposed film passes before the varying spot of light emitted by the light valve, a picture is recorded which is a copy of the film wrapped around the cylinder at the transmitting end.

The two rotating cylinders at the transmitting and receiving ends are maintained in synchronism by means of a 400 cycle current. This 400 cycle current is transmitted over the same line with the 1000 cycle "picture" current and at the transmitting end, the two frequencies are separated by means of a filter.

These briefly are the fundamentals of the process. The pictures transmitted and received by this equipment are 5 by 7 in. in size and can be transmitted in approximately 4 min. The line over which the pictures are transmitted is a standard telephone line used in regular telephone and telegraph service, and no preliminary precautions are necessary before placing the line in service for transmission of pictures. The system is equally adaptable to radio transmission.

New Developments of Adirondack Light & Power Co.

ACCORDING to the recent report of the Adirondack Light & Power Co., several projects are under way or have recently been completed, which will enable the company to meet the increased demands for power and which will effect operating economies. A new 6000-hp. hydroelectric plant at Sprite Creek was completed and placed in operation in February, 1924, and an additional 9000-hp. unit at the Spier falls plant was completed in December. Construction was started on a new 30,000-hp. hydroelectric plant at Beardslee falls and on enlarging the steam station near Amsterdam to 80,000 hp. capacity. Both projects are expected to be completed in the fall of 1924. The company has also contracted to purchase the entire output of the new 40,000-hp. plant of the International Paper Co. at Sherman island on the Hudson river, and is arranging to take into its system the entire output of the new 7500-hp. plant of the Moreau Manufacturing Co. at Feeder dam on the Hudson river as soon as that plant is completed.

Generating capacity of the system totaled nearly 131,000 hp. at the end of 1923. 70,000 hp. of additional capacity is under construction in plants owned by the company, which with the output regularly purchased from plants owned by others, rated at 47,500 hp., will make available generating capacity rated at more than 208,000 hp. by the end of 1924 without including power purchased under contracts for supplemental power.

New 80,000-Hp. Hydro Plant for Southern Power Co.

ANOTHER step in the waterpower development of the Southern Power Co. was assured when announcement was made recently of plans for the immediate reconstruction of the old Catawba hydroelectric plant, located 20 mi. south of Charlotte. The new plant will have a generating capacity of 80,000 hp., being of the same size as the Mountain Island plant, 12 mi. north of Charlotte, which was completed 7 months ago, and almost twice the size of the Rhodhiss plant, development of which was started a few months ago.

At present the Catawba plant has a head of 25 ft., and a generating capacity of 10,000 hp. The old dam and plant will form a part of the new dam, which will give an effective head of 65 ft. The new power plant will have four generating units of 20,000 hp. each, and will have a total generating capacity of eight times the present plant.

The new Catawba plant will be built by the Wateree Power Co., a subsidiary of the Southern Power Co., with its own organization. Contracts for the purchase of machinery will be let shortly.

A. E. C. Committee Reports on Muscle Shoals

AT THE REQUEST of Senator G. W. Norris, Chairman of the Senate Committee on Agriculture and Forestry, the American Engineering Council secured the appointment of a committee of competent engineers to study the Muscle Shoals situation. This committee recently submitted its report to the Administrative Board of the A. E. C. The committee report went into some detail on such questions as the amount of actual primary horsepower available, the value of the various projects, the ability to manufacture fertilizer on a large scale and many of the other technical and allied problems in the economic phases of the Muscle Shoals development.

Among its recommendations are the following points: First, that a Joint Committee of Congress should be constituted "to consider offers, conduct negotiations and report definite recommendations" as advised by the President in his message to Congress December 6, 1923.

Second, That no disposal should be made of any of the Muscle Shoals properties or rights until such Joint Committee of Congress shall have rendered its report.

Third, That in no event should any disposition be made of the power plants which is not in substantial accord with the provisions of the Federal Water Power Act.

In the course of its investigations the committee found nothing to justify the popular belief that the operation of the existing plants at Muscle Shoals will make substantially cheaper fertilizers immediately available, inasmuch as nitrates, however important, constitute but one of the three basic ingredients of commercial fertilizers, and consequently a considerable reduction in the nitrate cost would be reflected only to a slight degree in cost of marketable product.

The committee further found that recent developments of the synthetic process of nitrogen fixation had materially changed the entire outlook in the art and it is now quite possible that this process, for the use of which the so far unsuccessful Muscle Shoals Plant No. 1 was designed, may yet yield nitrate at a cost to compete with that obtained from Chile; and Plant No. 1, until recently considered a failure, may be the more valuable of the two constructed by the Government for the purpose intended.

A NEW POWER STATION is to be constructed by the New York Edison Co. with an ultimate capacity of 700,000 kw., it is announced by the General Electric Co., with whom the order for the first two turbine-generators has been placed. These turbine-generators have a rated capacity of 60,000 kw. at unity power factor, 25 cycles, 11,400 v., three phase, to run at 1500 r.p.m. These machines will operate at 350 lb. steam pressure, 700 deg. F. maximum temperature. They will be equipped with direct connected exciters and will exceed by 10,000 kw. capacity the present largest single unit machines now operating.

News Notes

R. D. Bean has been appointed chief engineer of the Brown Instrument Co., of Philadelphia, Pa.

Frederick Fosdick, president of the Fitchburg Steam Engine Co., of Fitchburg, Mass., died suddenly at his home on July 7.

Otis Elevator Co., of Quincy, Ill., will soon erect two new Heine water tube boilers of 150 hp. each to be equipped with hand stokers. Smith, Hinchman & Grylls, of Detroit, are the engineers.

R. A. Heitbrink, who has held the position of assistant manager for the Ohio Power Co., at Lima, Ohio, has been appointed manager of this company's properties at Freemont, Ohio. Mr. Heitbrink is a graduate of Purdue University.

Alex Dow, president of the Detroit Edison Co., was given the degree of Doctor of Engineering by the University of Michigan on Commencement Day, June 16. In 1911 the university conferred the degree of Master of Engineering upon him.

Thomas J. Sanders, formerly chief engineer at the American Hominy Co., Terre Haute, Ind., for 15 yr., has accepted the position of chief engineer of the Elevator Milling Co., Springfield, Ill. The American Hominy Co. plant at Terre Haute burned down this spring.

Joseph Binks, founder of the Binks Spray Equipment Co., has resigned as president and has been elected chairman of the board of directors. Harry D. Binks, formerly vice president, will succeed his father as president. The new president has been associated with the company for the past 20 yr.

Pennsylvania Power and Light Co. has awarded to William Cramp & Sons Ship and Engine Building Company a contract for two 28,500-hp. vertical I. P. Morris turbines with governors, and two 105 by 84-in. Johnson valves for the Wallenpaupack hydroelectric development in Pennsylvania. The turbines will operate under a head of 330 ft.

Armstrong Machine Works, Three Rivers, Mich., announces the acquisition of Otto J. Goeppinger, an engineer who has been closely associated with the paper industry for several years and who is qualified by experience and engineering training to make authoritative recommendations covering the efficient drainage of paper machine driers.

Wilfred Campbell, one of the leading turbine engineers of the country, and recently famed for his investigation of the protection of steam turbine disk wheels from axial vibration died at Schenectady, N. Y., on July 7 as a result of complications following an appendicitis operation. Since 1908 Mr. Campbell has been associated with the General Electric Co. He was born in Manchester, England, in 1884 and came to America in 1907. During the recent war Mr. Campbell was associated with Dr. Irving Langmuir and C. E. Eveleth, of General Electric, in connection with research and design work on submarine detectors. Since 1919 Mr. Campbell has been an engineer in the turbine department, and last December received an award from the Charles A. Coffin Foundation in recognition of his contribution to turbine research and design. The results of this long and fruitful research were presented before the Society of Mechanical Engineers on May 26 and will remain a monument to his energy and ability.

Peter G. Rimmer, for many years in charge of the Wilkes Barre office of the Ridgway Dynamo & Engine Co., has resigned the position which he has held for the last 2 yr. with the Scranton Electric Construction Co., and is again in charge of the office at Wilkes Barre. E. W. Quiggle, who has been in charge of the Wilkes Barre office during Mr. Rimmer's absence, is returning to the factory office at Ridgway, Pa.

Dwight P. Robinson & Co., has been authorized to design and construct an extension to the Seward plant built by them in 1920 for the Penn Public Service Corporation near Seward, Pa. This extension will consist of the installation of two new boilers equipped with preheaters and fans, one new stack and new boiler feed pumps. The stoker equipment will be the exact duplicate of that already installed.

Republic Creosoting Co. July 1st placed a new 8-still plant in service at Provo, Utah. This plant will handle the coal tar from Columbia Steel Corp. plant at Provo, making various oils for the Western market. D. C. Hunter will be superintendent. The plant at Indianapolis was dismantled of boilers and compressor to partly equip the Provo plant.

With one 40,000-hp. steam turbine unit ready for service, the new High Bridge steam power station of the Northern States Power Co., under construction at Saint Paul, is rapidly nearing completion. At present there are being installed in the plant two units of 40,000 hp. capacity each; the ultimate capacity of the station will be 200,000 hp., although the designs contemplate the installation of as much as 320,000 hp. High Bridge was designed by the Byllesby Engineering and Management Corporation, and is being constructed under the supervision and direction of that organization.

R. H. Carlisle, vice president of the Strong, Carlisle & Hammond Co., Cleveland, Ohio, died on July 5. Mr. Carlisle was born on a farm near Bedford, Ohio, in 1848. In 1887 he became associated with the late E. E. Strong and L. J. Hammond in the organization of the company which bears their names.

Southern Colorado Power Co., Canon City, Colo., is now installing one new 600-hp. B. & W. boiler and Westinghouse underfeed stoker which will bring the total boiler horsepower of the plant in the new section to 2400. Work is in charge of J. A. Linquist, superintendent of construction from Chicago for The H. M. Byllesby Eng. & Mgt. Corp.

In a program of expansion during 1924, power companies of Tennessee contemplate adding about 500 mi. of high-power transmission lines to the existing combined systems in the state, according to a survey completed by McGregor Smith, engineer of the public utilities commission. It will be possible to transmit power

through an interconnected system from Bristol to Clarksville and on to Hopkinsville, Ky., before the year ends, Mr. Smith believes.

WHAT IS DECLARED to be the largest order of automatic substation equipment ever placed in the United States has been contracted for by the Department of Street Railways of the City of Detroit with the General Electric Co. The order calls for a total of ten 2000-kw. and four 1000-kw. synchronous converters, aggregating 24,000 kw. All these proposed substations, which will greatly increase the facilities for efficient service on Detroit's street railway system, are being designed by Smith, Hinchman & Grylls, consulting engineers and architects of Detroit. Both semioutdoor and indoor type substations are to be used but all of the transformers will be of the outdoor type.

THE CITY OF MONMOUTH, Ill., is drilling two wells on lot adjacent to the plant of the Illinois Power & Light Co. and will install electric equipment so that the steam plant now in use will be abandoned. This work will take about 1 yr. Nels Jessen is the chief engineer.

Catalog Notes

THE EUCLID CRANE & HOIST Co. of Euclid, O., has issued a new 16-page catalog describing their line of cranes and hoisting equipment. It is well illustrated and shows the application of hoisting equipment in various industries.

WESTINGHOUSE ELECTRIC & MANUFACTURING Co. of East Pittsburgh, Pa., is distributing a new publication, known as C 1699, entitled, Steel-Clad Distribution Transformers, Type SK. This pamphlet is descriptive of the newly designed type of transformers, and while it is of interest to all who are connected with the electrical industry, it will recommend itself especially to power-plant and transmission engineers.

"ORIGIN, DEVELOPMENT, RESULTS OF ELESCO," is the subject of a booklet which is published by The Superheater Company of New York and Chicago, manufacturers of Elesco Superheaters. It gives in brief form the history of The Superheater Company and the growth of its operations up to the present time when it occupies the unique position of manufacturers of superheaters for every type of steam boiler in Locomotive, Marine and Stationary services. The development of the use of high degree superheated steam is traced from the earliest experiments of the late Dr. Wilhelm Schmidt of Cassel, Germany, to the present tendencies in steam generation in this country. An interesting paragraph is the one that explains the origin of the trade name "Elesco" applied to the products of that company.

SINGLE STAGE Underwriters' fire pumps, as specified and approved by the Associated Factory Mutual Fire Insurance Co. and by the Underwriters' Laboratories, of Chicago, are described in a four page leaflet issued by the De Laval Steam Turbine Co., of Trenton, N. J. The De Laval single stage centrifugal pump is claimed to be more simple and compact then the multistage pump formerly specified for this service and to be a highly reliable machine, eminently free from troubles due to maladjustment or lack of care. The pump casing is split horizontally, so that all internal parts and passages are accessible upon removing the casing cover. The pump can be driven either by electric motor or by the De Laval velocity stage turbine, as approved by the Underwriters. In an accompanying leaflet the use of single stage fire pumps in a number of the large mills at Lowell, Mass., is described.

"REFRACTORY FACTS" is a 158-page handbook published by the Walsh Fire Clay Products Co., of St. Louis, Mo. The handbook takes up a general study of fire clay from a physical and a chemical standpoint and then goes into a complete description of how refractories are manufactured at the Walsh plant. The latter part of the book contains data tables and general information applying to the application of refractories.

SANFORD RILEY STOKER Co., Worcester, Mass., has recently issued a new bulletin covering the Lateral Retort Under-Feed Stoker. This bulletin discusses the advantages of this type of stoker; shows how the fuel and air are automatically controlled and then gives a number of sectional views of boiler installations showing how the stoker is applied.

M. A. HOFFT Co. has just had issued a new booklet describing in detail National furnace arches. The booklet points out the lower maintenance costs, outstanding advantages, ease of installing and replacements, as well as other features of the National arches. The publication is obtainable by addressing the company at 814 West Washington Ave., Indianapolis, Ind.

BEARING METALS and hints for making lined bearings and making them give good service, are covered in "The Magnolia Metal Bearing Book," which has been published by the Magnolia Metal Co., 115 Bank St., New York City. The first part of this 96-page handbook discusses the general properties of bearing metals and then goes into the advantages of Magnolia metal for such service. The second half of the book tells just how a bearing may be relined and takes up all of the steps in this work.

"A SHORT STORY IN PICTURES," is the subject of a booklet issued by the Garlock Packing Co., of Palmyra, N. Y., which shows photographs in the factories of the Garlock Packing Co. The photographs are shown to prove the claims that Garlock packings are quality controlled packings, having the same service stamina today and tomorrow that they had yesterday.

REX CHAINS AND CONVEYORS are covered in Catalog No. 210, which is now being distributed by the Chain Belt Co., of Milwaukee, Wis. This 512-page catalog covers the complete lines of Rex chain conveying machinery and concrete mixers in a comprehensive way and also contains a large amount of technical data which will enable engineers and users to select the equipment best suited to their needs. The illustrations suggest the wide range and possibilities in the application of this type of material handling equipment.

CONSIDERABLE GENERAL INFORMATION on steam trap practice is given in a new booklet on the Armstrong steam trap which is now being distributed by the Armstrong Machine Works of Three Rivers, Mich. Besides describing this type of trap and giving some of the advantages of the principle on which it operates, tables are also presented which show the capacities at different pressures and it includes instructions for the installation and maintenance of such traps.